THE EAST AFRICAN AGRICULTURAL JOURNAL

Issued under the Authority of the East African Governors' Conference and published every other month
JANUARY, MARCH, MAY, JULY, SEPTEMBER, NOVEMBER

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Coffee Quality

The task of elucidating the factors that govern coffee quality is beset with difficulties. Good field husbandry and factory practice can contribute much in giving the desired size, colour and evenness to the raw coffee; the special requirements of the roast are more difficult to attain, whereas little is known of the conditions that make for the desired acidity, body and flavour of coffee in the cup. The main difficulty in correlating the liquoring properties of coffee is that it has not been possible to define liquoring properties in chemical terms. The personal equation of the taster also plays an important role, thus making it difficult to standardize any coffee samples under consideration.

The scientific literature on the subject of coffee liquor is scanty and not very helpful, as it usually gives no useful clues that may lead to direct methods of investigating the true meaning of differences in the liquoring properties of coffee. Such differences, which often vary greatly between neighbouring estates, play a profound part in the economy of coffee production, more especially in East Africa, where such a wide range of prices obtains. The necessity for making some progress towards the solution of this intricate problem has now become urgent.

The outlook for making early progress by studying the nutrition of the coffee tree or by comparing bean analyses with unstandardized terms of liquor, offers little promise. It is therefore pleasing to read an account of some headway in the matter of elucidating coffee quality that has been

made by investigators in Brazil and Costa Rica.[1] The purpose of this note is to draw special attention to these coffee quality investigations and to discuss their possible application to the coffees of East Africa.

An account of certain Brazilian investigations dealing with the effect of harvesting and factory methods on coffee quality may be summarized as follows:—

1. When cherries were allowed to dry slowly on the tree in normal, harsh, or "Rio-flavoured" regions, the resultant coffee was harsh, whereas similar drying on the tree in recognized mild-flavoured areas gave a mild coffee. With such slow drying of the cherry, the specific natural flavours are retained in the properly prepared coffee.

2. It was found also that cherries from regions known as good gave a coffee of mild beverage only when subjected to correct harvesting and factory treatment. This consists in the main of slow drying with constant stirring of completely ripe-picked cherries such that *no fermentation of the pulp occurs*. When such correct methods were neglected, and mixed stripped cherries, even from regions famous for high quality, were allowed to ferment in the pulp, the resulting coffee was inferior in beverage. In the above two investigations it will be noticed that the coffee was prepared by the normal Brazilian method of drying the coffee in the cherry and then decorticating.

3. Another investigation compared the quality of coffee from different sources, when prepared by pulping the cherries and then washing and drying the beans. It was found that all samples pulped, from every region, always gave a mild beverage. The control samples, which were not pulped but were allowed to ferment in the cherry, gave a beverage with a disagreeable flavour varying with the degree of fermentation that had taken place.

4. A further test in tracing the harsh or mild quality of coffee was carried out by spraying cherries of known poor quality, while on the tree, with a sugar solution containing cherry yeasts which are normally associated with high quality. It was found that there was a difference in the quality of the coffee from the sprayed trees. The sprayed cherries never had the harsh or "Rio" flavour.

5. The effect of inoculation with a more suitable micro-flora was tested by adding the pulp of cherries from a plantation yielding mild coffee to fermenting cherries from a plantation known for its "Rio-flavoured" products. It was found that the resultant coffee had a pronounced mild flavour.

In the Costa Rica investigations, using the wet fermentation method of preparation, it was found that when pulp from a superior quality coffee was added to another fermenting pulped coffee, the resultant beverage was of a higher quality.

It had been thought that the harsh or "Rio" flavour, characteristic of coffee originating from certain defined regions in Brazil, was due to the nature of the soil. The above investigations, carried out independently in Brazil and Costa Rica, showed that by proper treatment it is possible to produce mild coffees in the regions hitherto known for their harsh coffees. It has been shown that the nature of the fermentation and the resulting quality depend largely on the specific yeasts that predominate in the micro-flora of the coffee cherry.

It is supposed that the products secreted by the organisms in the pulp have a profound influence on the quality of the coffee bean, as the cell wall of the latter is more

[1] "Recent Efforts for the Improvement of Brazilian Coffee," in the *Monthly Bulletin of Agricultural Science and Practice*, International Institute of Agriculture, Rome; January, 1937.

or less permeable to secreted ferments. It is believed that the yeasts secret a ferment which penetrates the beans and provokes the mild flavour, or else that they secrete something specific which inhibits the activities of other less suitable organisms which are normally responsible for the harsh "Rio" flavour.

A survey of the predominant micro-flora, in good and bad plantations respectively, showed which were the most beneficial, and pure cultures were separated out. It has been shown that when such pure cultures of yeast are added to previously sterilized cherries, the fermenting processes and also the resulting flavour of the beverage are altered. The practical application of this study lies in altering the micro-flora living on the cherry and thus forming associations in which the beneficent yeasts of high quality coffee predominate.

It will be appreciated that the above-mentioned results, quoted by M. Rogerio de Camargo of Brazil and Dr. C. Ricardo of Costa Rica, offer a direct line of approach for investigating variations of coffee quality in East Africa. They appear to offer more promising lines of approach than bio-chemical studies of the metabolism of coffee bushes and analyses of coffee beans, when one considers that analytical data need not necessarily explain the finer differences in the liquor of samples of coffee. Again, field and factory trials involving inoculation with the predominant micro-flora living on certain cherries or pulp are such that they can be initiated in a simple manner. Then, if these tests show sign of promise, they could be followed up with a field survey of the types associated with good and bad liquor and pure cultures of beneficial micro-flora could be separated out.

Lest the above investigations should lead to too optimistic views being held about the possibilities in East Africa, it might be well to refer to some of the major difficulties involved. In the first place, the work dealt mainly with the extremes of harsh or "Rio-flavoured" coffee against Brazilian mild coffee, whereas here we have to deal with differences of liquor within a series of mild Arabica coffees. The Brazilian investigations again deal largely with coffee that is stripped off the trees, dried and decorticated—it being found that pulped and washed coffee always gave a milder flavour. However, work in Costa Rica has shown that the addition of selected pulp can improve the quality even of coffee prepared by the wet method, so that it may be found that fermentations produced by various micro-flora may have an effect even within the East African mild series.

Those working on coffee in East Africa are indebted to the American workers for thus indicating a possible direct line of approach in investigating the quality of local coffee, and it is to be followed up by the Kenya Coffee Team with the coming crop.

G. H. G. J.

The Trend of Population

Recent studies of population trends have yielded results of far-reaching importance to agriculturists, as indeed to all sections of the community. The decline in the size of families in Britain as compared with a couple of generations ago is noticeable. For a time this was not inconsistent with an increasing total population, as there was a decline also in the death rate. The removal of avoidable causes of death cannot go on indefinitely, however, and the decline in the birth rate must shortly begin to show its effect.

In a study by Dr. Enid Charles, published by the London and Cambridge Economic Service, the future population

of England and Wales is forecasted on three different assumptions: (*a*) that the average size of families and the average expectation of life will remain as in 1933; (*b*) that fertility and mortality will both continue to decline at the rates at which they have declined in recent years; and (*c*) that fertility will increase to the level of 1931 (one of the best post-war years), while mortality will continue to decline. Under assumption (*a*) the population would increase from the present 40.6 millions to a peak in 1945 of 40.9 millions, and thereafter decline at an increasing rate, to 38.5 millions in 1965 and 20.0 millions in 2035. Under assumption (*c*) a peak would be reached at 43.7 millions in 1965, declining to 33.6 millions in 2035. Under assumption (*b*) there would be a continuous decline from the present time to 35.8 millions in 1965 and 4.4 millions in 2035.

Sir William Beveridge recently voiced the conclusion that, unless things altered, one-quarter of the population would disappear in each generation. He forecast a population of 20 millions in 2037 and only 5 millions in 2137.

Which, if any, of these assumptions will actually materialize can only be surmised. The families of a dozen or so, common in the Victorian period, are with us no longer. The uncertainties of the present period may in one way or another be a deterrent to potential parents. But no one can ignore the effect of the dissemination of knowledge of contraception, or the social influences militating against early marriage. Least of all can one ignore the positive correlation of low standards of living and high birth rate, and it is a disturbing conclusion that, under present world conditions, social progress appears to lead to population decline.

Other studies show that the increase in world population in the eighteenth century was almost entirely due to a decline in the death rate. The plain fact is that the "net reproduction rate," i.e. the number of surviving daughters born to the average woman in her lifetime, is now less than unity. It is as low as 0.73 in England and Wales. If this continues it results in a population decrease accelerating by geometrical progression.

Now this movement is not peculiar to England and Wales. In the *Economist* of 27th June, 1936, a table is given showing the following net reproduction rates (for the year 1933 when not otherwise stated):

Germany	0.70
England and Wales ..	0.73
Sweden	0.73
France	0.82
Scotland	0.91
Denmark	0.91
Italy	1.18
Portugal	1.29
Bulgaria	1.30
European Russia	1.70
U.S.A. (1930)	0.98
Australia	0.98
New Zealand	0.98
Canada (1931)	1.32

In Germany there was a spectacular increase from 1932 to 1934, "but there is nothing to show that there has been any permanent recovery in German fertility. There was a considerable postponement of marriages everywhere." In almost all the countries mentioned there has been a long-period decline in fertility. In Bulgaria it fell from 3.18 in 1901-1905 to 1.30 in 1933; in Italy from 2.0 in 1921 to 1.18 in 1933.

These observations are of considerable importance to agriculturists when the long period is considered. Will there be a heavy decrease in the quantity of food and raw materials required, and in the quantity of land required to produce them? Or will the continued increase of the eastern and African races be accompanied by a rise in their standards of living; will they, for

some time to come, step into the economic place vacated by the declining white populations? The general tendency is for perishable produce to increase in importance at the expense of the main food staples. The European peoples, who are at present the chief consumers of perishable produce, will consume less food in total. Will the eastern and African peoples follow them in turning from cereals to fruit, milk, butter, etc.? In the production of perishables intensive culture is the general rule, and land plays a less important part. Will the demand for land for agriculture decline, destroying a large amount of farm capital? Or will the land be transferred to other uses, such as game reserves, golf courses and other recreational purposes?

To settlers in East Africa the facts are of special importance. The parts of the Empire inhabited by the white peoples are approaching a stage of declining population. This applies to Australia and New Zealand. The probability is that it applies or will shortly apply to Canada, South Africa, Southern Rhodesia, and Kenya. How are the open spaces going to be filled up? How are the values of land going to be maintained? How much reliance can be placed on emigration from Britain, when the population of that country is in a state of decline, and other portions of the Empire are competing for any potential emigrants that there may be? The subject opened up by these researches is certainly an arresting one.

V. L.

Current Notes

Cotton Seed

Increasing quantities of cotton seed are available in Kenya for the cattle industry, and it is a pity that the consumption at the present time is so small. Cotton seed is a cheap, protein-rich food, useful for incorporating in balanced rations for milking cows. The chief drawback to its more widespread use is the fact that the samples contain a heavy covering of lint, which renders it an unsuitable food for young stock or for any stock if fed in excessive quantities. Experiments have been carried out at the Plant Breeding Station (Kenya) with the use of cotton seed, and it is found that up to 4 lb. daily can safely be fed to one animal. The seed is rolled prior to feeding, but should not be stored for a long time after rolling, as the oil will tend to go rancid. Excessive feeding of cotton seed will produce a tallowy butter, and therefore it is unwise to recommend the use of more than 4 lb. per beast per day. It is to be hoped that sufficient use will be made of this relatively cheap food to justify the importation of de-linting machinery, so as to prepare a sample the digestibility of which will be assured. Some farmers prefer to soak the seed in preference to rolling it, but great care must be exercised if this is done, as cyanogenetic glucosides can be liberated in the process.

In addition, cotton seed is useful as part of the ration for fattening bullocks. The feeding of a mixture containing cotton seed, starchy foods such as maize or barley, and silage constitutes a method of finishing off adult steers. More attention will have to be paid in future to proper finishing of beef cattle if export is to be considered.

Finally, it should be emphasized that cotton seed is not a suitable food for young stock, and should never be fed to adult stock in excess of 4 lb. daily.

Hosier Portable Poultry System

Results are now available for a year's working of this system, originally introduced into Kenya by Mr. G. R. Morrison. The following figures, which represent number of eggs per bird per month during 1936-37 on Vron Farm, Menengai (manager, Mr. C. Corbett), illustrate the success of the system:—

No. of eggs per bird per month, 1936-1937

April	16.4
May	17.9
June	21.5
July	21.3
August	16.6
September	18.3
October	18.3
November	15.4
December	14.9
January	13.7
February	14.0
March	15.2
Average	17.0

In addition to a high level of production, considerable benefit has been obtained from the manure applied to the land. It was interesting to note that the lowest figure, reached in January during the dry season, was very easily raised by the feeding of marrowstem kale to the birds. No skim milk has been fed to the birds in the above experiments, but animal protein was fed in the form of biltong (made from an old working ox) when meat meal became difficult to procure in the country.

Bacon Carcass Competitions

At the recent Agricultural Show held in Nairobi it was interesting to note that in the bacon carcass competitions the prize-winners were all the progeny of cross-bred sows sired by a pure-bred Large White boar. Pure-bred Large White stock appeared to be rather too slow maturing. On the other hand, in the pig classes, entries were almost exclusively Large White, and the dearth of stock of other breeds in the country at the present time is very pronounced. It is a well-known fact that cross-bred progeny mature more rapidly and require less food to finish than the pure-breds. At the same time, it must be remembered that in almost any litter which are the progeny of a cross-bred sow some of the pigs will not be of bacon type, and this was well shown in the entries for live pigs in the bacon classes, where an otherwise first-rate entry of three pigs, two of which were of ideal bacon type, was spoilt by the third being heavy in the shoulder and short in the middle. Yet all three were litter brothers or sisters.

The problem of the correct type of bacon pig for Kenya conditions therefore still remains to be solved.

Store Raising

Increasing attention is being paid to the fact that certain areas in Kenya, particularly at the high altitudes, are ideal country for raising store cattle on account of the large area of rough grazing cheaply available and the fact that cattle appear to "grow out" under the conditions obtaining there. At the same time, they do not finish readily under these conditions, on account of the long distances it is necessary to walk, the large amount of very coarse roughage consumed, and the relatively low temperatures. There is therefore an increasing tendency towards the purchase of store steers for finishing in the lower and hotter country, particularly in the Star-grass areas, and results to date are extremely promising. It appears that cattle can be finished in these areas during the rains without additional feeding. This country may be faced with the same problems as Great Britain in the purchase of steers, because, owing to the expansion of the dairy industry, steers are becoming more and more of purely dairy type, as farmers are using an increasing number of bulls of purely dairy breeds. It is to be hoped that when farms become stocked with dairy cows, farmers will serve their lower yielding milking animals with a bull of a breed such as the Aberdeen Angus and produce a really useful type of beef animal.

Pedigree Flax in Kenya

A considerable acreage is being seeded under Liral Crown pedigree flax during 1937. It is recommended that the seed should be drilled, but where this is done it must be sown very shallow, not more than half an inch deep. Dressing of the seed with a mercurial dust, such as Agrosan G or Abavit, increases the germination and produces a more even stand. As this variety has a very weak straw, it should not be planted early on very rich land, or it is liable to become laid and twisted, with consequent uneven ripening. It is recommended that the crop should be hand pulled, stooked and threshed stationary. This ensures the production of seed of high germinating capacity, and enables it to be separated from the weeds in the process of hand pulling.

Multiplication and Issue of a New Wheat

Over 3,000 bags of the new wheat, No. 58.F.(L.1), have been issued in Kenya this

year. This wheat is resistant to the four known Kenya physiologic forms of stem rust, is a good yielder and moderately quick maturing, and is suited to the lower altitudes up to 7,000 feet.

The method adopted in the multiplication of this, and in fact of all wheats, may be of interest. As soon as a small amount of seed is available of the strain to be increased, this amount is issued to a farmer for multiplication and trial under agreement. The agreement is that the Department has a lien on half the crop, and on any of the grower's half which he does not require himself. The Department generally disposes of its share to other farmers at a fixed price, so that there may be several growers of the crop in the second season. Other requirements specified in the agreement are that the wheat be sown on land free from volunteer wheat of another variety and that all reasonable steps be taken to keep the seed pure.

Should the wheat prove unsatisfactory after one or more seasons' trial, it is all sent to the mills, and so in this way is withdrawn from circulation.

This method of multiplication and trial of new wheats in co-operation with growers has proved successful, and enables new wheats to be issued sooner than if the Department had first to test but not multiply them over a period of years.

The rapidity of multiplication under approved growers can be shown by the fact that in 1935 just over 100 bags of wheat No. 58.F.(L.1) were available for sowing, but in 1936, due partly to the utilization of two seasons in the year in the case of a few growers, this amount had been increased to over 3,000 bags. Some growers, by stopping up alternate drills so that the wheat was sown at double the normal spacing between rows, i.e. 14 in. or 16 in. instead of 7 in. or 8 in., achieved increases of forty- or fifty-fold over their original seed.

Trees and Tree Planting, Trans Nzoia, Kenya

The heavy rain has assisted considerably in giving the coronation tree plantations a good start. At the experiment station, demonstration windbreaks and shelter belts are being planted. One very cheap narrow windbreak consists of three rows of trees planted at 12 ft. by 12 ft. To deflect the wind upwards, the first row comprises the short species *Duranta, Dovyalis macrocalyx,* and *Callistris robusta.* The second row has *Cupressus lusitanica,* which will be of medium height, and the third row of tall growing trees has *Acrocarpus fraxinifolius.* Maïze has been planted between the rows.

A standard belt, 60 ft. wide, has been planted at 12 ft. by 12 ft., and only indigenous trees employed. There are two rows of short species, viz. *Duranta* and *Dovyalis macrocalyx,* followed by two rows of medium-sized trees, viz. *Markhamia hildebrandtii, Spathodea nilotica* (Nandi Flame), and *Calodendron capense.* Then three rows of tall growing trees, viz. *Linociera welwitschii, Vitex keniensis* and *Premna maxima.* This is an experimental belt which has not been proved. The farmer desirous of planting a quick growing shelter belt cannot go wrong if he employs *Cupressus lusitanica* for the short trees, *Grevillea robusta* as the medium, and *Eucalyptus saligna* as the tall growing species. For the edges of paddocks the outside rows of short species should be spiny, e.g. Kei Apple, *Duranta, Dovyalis,* and Mauritius Thorn. As a last word on this subject, sceptics who doubt the value of Podo, Cedar and Olive on the sandy

soil near Kitale should visit the Experiment Station, where Podo planted in 1935 is now four to five feet in height.

Paspalum Dilatatum in Trans Nzoia

Considerable interest has been taken in the well-known *Paspalum dilatatum* as a drought-resistant fodder grass for reverted maize land. There is no doubt about the merits of this grass; it has been well tried in the Trans Nzoia under a variety of conditions. In low-lying damp situations, on exposed sandy ridges, on worn-out maize land, under gums or wattle, *Paspalum dilatatum* seems to do extremely well wherever it is planted. A well-known local farmer has even found *Paspalum* competing successfully with Couch grass (*Digitaria* sp.). The grass is best established from roots, but seeding can be equally successful. *Paspalum* paddocks require "renovating" every two or three years. This is merely a process of opening up the soil by means of a heavy cultivator or similar implement.

R. J. L.

A Book for the Coffee Planter

The Kenya Government Printer has recently published, at a price of Sh. 5 (postage 50 cents), a book entitled *Coffee in Kenya.* It is a collection of essays by the members of the Department of Agriculture, together with one by the Director of the British Meteorological Service, the whole under the editorship of Mr. J. McDonald. The subjects treated are the climate of coffee aras in Kenya, coffee soils, cultural practice and factory treatment, insect pests and diseases, and the economics of coffee production. In a foreword, the Director of Agriculture points out that, while a textbook of coffee culture is not intended, the planter will find in it some elucidation of the problems met in Kenya plantations. This important book should be in the hands of all coffee planters.

Ocean Freights

Pronounced increases in ocean freight rates are causing some concern to primary producers in East Africa. Since the trough of the depression, the rate on maize has risen from 17/6 to 32/6, on sisal from 35/- to 45/-, on coffee from 65/- to 72/6, on cotton (Europe) from 30/- to 40/-, on cotton seed from 22/6 to 30/9, on tea from 45/- to 55/-.

Increases of the magnitude shown by these examples seem calculated to nullify the greater part of the effect of enhanced overseas prices. They are no local phenomenon, however. Parcels rates on wheat from Australia to European ports have increased from 20/- per ton in the second quarter of 1933 to as much as 45/- per ton in the corresponding quarter of 1937. Charter rates, which were quoted at 20/- per ton in June, 1932, had risen to as much as 53/6 in April and May, 1937. The *Economist* index of shipping freight rates has risen from about 80 in the middle of 1932 (1898-1913=100) to 157 in June, 1937. "According to the index of the League of Nations, the volume of world trade has practically recovered to the pre-depression level. And, since the world's shipping capacity is still smaller than in 1927, the rise of freight rates above the level of eight years ago is scarcely surprising."

Hay

The observer cannot but be impressed with the large area in Kenya which grows a heavy crop of grass in the wet season. The potential supply of hay must be very great, but little attempt is made to save any. The carrying capacity of land is its

capacity during the most unfavourable season. There is much talk of overstocking, but overstocking is a relative term. For some time after the rains there is in many areas, in fact, a condition of serious under-stocking, with the result that the grass exhausts itself in seed production and the turf becomes thin in the bottom. The nutritive material passes into the seed and stock are forced to exist on material consisting mainly of crude fibre. When this disappears there is a severe strain on the scant herbage, with the result that recuperation is often only partial.

There is a vast field for evening out the supply of nutritive material over the year, reducing waste in periods of abundance and lessening the strain on the land in periods of shortage.

In native reserves the communal tenure of grazing land raises difficulties, but there may be areas in which the possibility of haymaking is worthy of examination. Conservation of hay would not, of course, provide a permanent solution of the overstocking problem, as the struggle for existence of the live stock would no doubt be eventually resumed at a higher level. With the development of a meat industry this may be less of a danger than formerly.

The value of hay as a fodder reserve on European stock farms has been continually stressed, and the appearance of a large swarm of locusts in Kenya has given additional point to the matter. It is essential, however, that hay should not be confused with what in England is called "fog," namely dead grass. Hay is the dried product made from grass cut in the flowering stage, before all the nutritive material has passed into the seed. In this stage the nutritive material is not lost by shedding of seed and the plant has not exhausted itself in the effort of reproduction.

East African Coffee-marketing

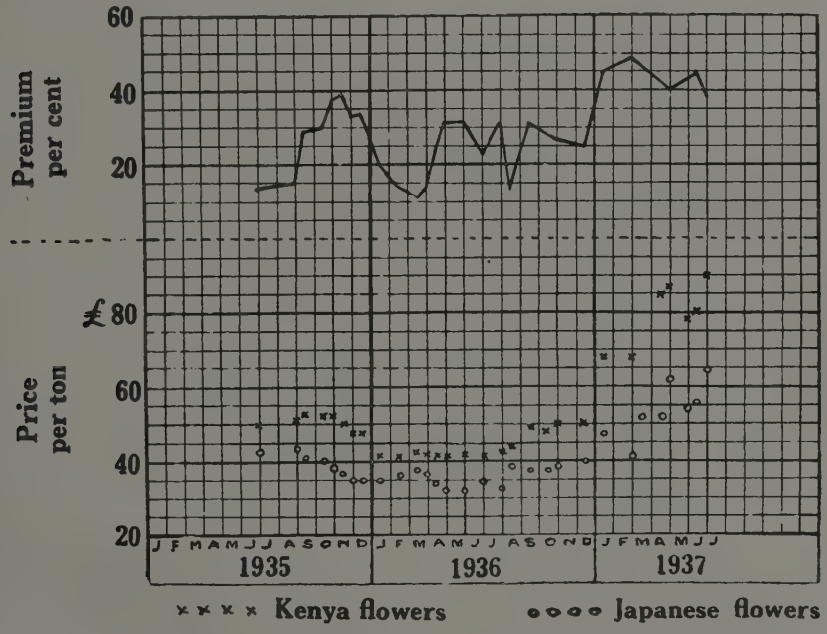
Kenya coffee planters may apparently congratulate themselves on their position in the United Kingdom coffee market, though one would not receive the impression that there is undue complacence in local coffee circles. According to a writer in the *Planters' Chronicle* of 10th July, 1937, Kenya coffee, together with Costa Rica, is backed up by powerful vested interests. Among the planters "are some of the richest financiers in London . . . who, of course, are in a position to lay down the 'coffee law' and dictate the 'quality law' in London." "The preference given to Indian coffee in the United Kingdom is only nominal and not effective, for other countries, supported by their respective Governments, can and do manipulate their exchanges to suit their trade. While this back-door influence helps the non-Empire coffee to steal a march over Indian produce, it gives the African producers a special advantage to successfully compete with the Indian producers in the United Kingdom market, in spite of their admittedly inferior goods."

Possibly East African producers have not been sufficiently appreciative of their economic advantages. Fortunately, however, there is little sign of a tendency to adopt a narrow geographical viewpoint in furthering the interests of Empire coffee. As always, unity is strength.

Pyrethrum Prices

The course of pyrethrum prices is gratifying to those who have been connected with the development of the industry in Kenya, not only on account of the general rise in the price of the product, but also on account of the substantial premium in favour of the Kenya product which has emerged. The accompanying graph has

been drawn up by plotting the prices of Kenya and Japanese flowers when both were quoted in the same report. In the upper part of the graph the premium is shown expressed as a percentage of the price of Japanese. The month-to-month variations in the premium are caused in part by the age of the product. When quotations were given separately for old and new crop Japanese, the price of new crop was taken. The sale of Kenya flowers on the basis of a guaranteed pyrethrin content has no doubt contributed largely to the premium, as well as the efforts to ensure that only strains with a high pyrethrin content should be planted.



V. L.

Farm Fencing—Part I

By L. A. ELMER, *Assistant Agricultural Officer, Department of Agriculture, Kenya Colony.*

These notes have been compiled to help the man who knows little or nothing about fencing. A number of experienced settlers and hardware firms have been good enough to take a great deal of trouble to help to make them as complete as possible, and I acknowledge their assistance with gratitude.

Erecting a fence, like any other building work, requires attention to details. Thoroughness and care are essential; a badly made fence is an eyesore and a continual source of annoyance and expense. The novice would do well to examine fences in his neighbourhood and make careful notes.

As will be seen from the following pages, the first steps should be taken many months before the actual construction is started. A hasty, ill-organized start will be costly and the results poor.

Much fencing is likely to be done in the future in East Africa; already many Africans have started mixed farming in the native reserves and are paddocking.

A good investment on every farm would be a plantation of trees suitable for fencing posts. Readers are advised to obtain a bulletin issued by the Forest Department called "Trees Suitable for Planting on Farms in the Highlands of Kenya," in which will also be found lists of hedge plants suitable for different regions. A few notes on hedges are given towards the end of this article.

It should be remembered that animals often try to climb through a fence. The closer the posts are spaced the more rigid a wire fence will be, and the easier for animals to get through. The space of fence between two posts is called a panel. If the panel is long and the spacing of the wires is maintained by droppers, an elastic panel is obtained which will give to the pressure of an animal, thus making it difficult to squeeze between the wires. If the straining posts are too close together the fence loses its elasticity. Wires should not be stapled tightly to fence posts; they must be able to move with contraction and expansion and allow the strain of a blow to be distributed along the whole length from one strainer post to another.

In a district where game is unaccustomed to a fence it is a good practice to cut paraffin tins into ten pieces each and hang two or three pieces on each panel. This makes the fence more noticeable and therefore less likely to be damaged.

It is claimed for steel fencing posts that they form a protection for stock in that they "ground" currents of electricity carried by the fence during thunderstorms. With a wood post and wire fence the same result would be obtained by earthing a double wire or metal dropper at intervals, preferably near posts.

Curves and turns in a fence should be avoided as much as possible, as they necessitate an excessive number of stays.

When buying manufactured fencing materials it is best to select well-known brands which have been proved by many years of experience.

It should be remembered that shade is most beneficial to stock of all kinds. Trees should always be protected from horses, who have a habit of ringbarking any tree they can reach. Poisonous trees and plants should be sought out and removed, for an animal in an enclosure will some-

times nibble at a poisonous plant that he would not touch on open range.

Common mistakes in fencing are as follows:—

(1) Stays or struts holding straining posts fitted too high, and not footed. They should be fixed just below two-thirds of the height of the post above ground level, with the ends footed against something immovable.
(2) Stays too short. The higher the fence the longer the stays should be; 12 feet is a good length for a fence 4 feet high.
(3) Fence posts unnecessarily long.
(4) On broken land the lower wire either touching the ground or too high, so that animals can get over or under the fence.
(5) Using too many posts.
(6) Using gate posts as strainers.
(7) Omitting foot plates on strainers and on posts in hollows.
(8) Straining the wires when the ground is wet.

Types of Fences

Boundary Fences for Cattle

The minimum type of boundary fence for cattle is prescribed in the Fencing Rules, 1935, under the Kenya Fencing Ordinance, 1929. The specifications are as follows:—

Part I

Fencing Requirements

Fences shall be 4 ft. high, consisting of one top strand of barbed wire and lower strands of plain wires, all tightly strained and secured to strainers and strands firmly embedded in the ground to the minimum depths and at the minimum interval hereafter specified.

Droppers shall be provided as hereafter specified to stiffen the wiring between supports at standards or strainers.

Gates shall be single folding, 10 ft. wide and 4 ft. high, suitably hung and with fixings satisfactory to the Chief Veterinary Officer.

The five strands of wire shall be spaced at 9 in. intervals, the bottom strands being fixed 12 in. above the ground.

The barbed wire of the top strand shall be two-ply galvanized steel wire with four-point barbs 6 in. apart, and with a minimum breaking strain of 950 lb.

The plain wire of lower strands shall be galvanized steel wire, round or oval in section, with a minimum breaking strain of 1,100 lb.

Tie or binding wire shall be galvanized steel wire No. 12 Imperial Standard wire gauge.

The strainers, standards and droppers shall be of steel as Specification I or of wood as Specification II hereunder.

Steel and wood strainers, standards and droppers in accordance with Specifications I and II respectively contained in Part II and Part III of these Rules may be used in combination.

Part II

Specification I—Steel

All steel strainers, standards and droppers shall be of suitable section, provided with earth plates as necessary to ensure stability.

Strainers shall be provided at maximum distance apart of 450 yards and at all corners and openings in fencing, with feet embedded in the ground to a depth of 3 ft.

Strainers shall be 7 ft. 6 in. long, fitted normally with one strut, and weighing not less than 30 lb. complete.

Strainers at corners shall be fitted with an extra strut.

Standards shall be provided between strainers at maximum intervals of 15 yards, with feet embedded in the ground to a depth of 2 ft.

Standards shall be 6 ft. long, weighing not less than 14 lb.

Droppers weighing not less than 1½ lb. shall be provided and looped between the wire strands, three being equally spaced in each interval between adjoining standards of strainers.

Part III

Specification II—Wood

For the purpose of this specification, heartwood of cedar, *muhugu, mueri,* brown olive and other hardwoods, if well seasoned and properly impregnated with an efficient wood preservative, shall be deemed to be durable wood. Wood not complying with the above

condition shall be deemed to non-durable wood.

Strainers shall be provided at maximum distances apart of 450 yards, and at all corners and openings in fencing, with feet embedded in the ground to a depth of 3 ft.

Strainers shall be 6 in. minimum diameter and 7 ft. 6 in. long, normally with one framed strut, and all of durable wood.

Strainers at corners shall have an extra strut.

Standards (posts) shall be provided between strainers at maximum intervals of 20 yards, with feet embedded in the ground to a depth of 2 ft.

Standards shall be 4 in. minimum diameter and 6 ft. long, of durable wood.

Droppers shall be provided, and four equally spaced in each interval between adjoining standards or strainers.

Droppers shall be of durable wood, 1½ to 2 in. diameter, or of non-durable wood 2½ in. diameter.

Other Cattle Fences

Cattle are more inclined to get out of a small paddock than a large one. Descriptions are given below of fences suitable for both large and small and for calf and bull paddocks.

The fence described by Government is most suitable, but others are described which will be a guide in constructing fences not on boundary lines.

1—*From a Kenya Farmer*

Large Paddock

Posts.—Cedar or olive, 6 ft. long, 2 ft. in the ground, 60 ft. apart; holes bored at appropriate intervals for threading wires, as staples will not stay in cedar and will not drive into olive.

Strainers.—7 ft. 6 in. long, 3 ft. 6 in. in the ground, quarter of a mile apart, more or less, depending on the land, foot plates fitted, well stayed about half way up.

Wire.—Five wires (but six are better), oval steel, 10 x 12 or 11 x 13 gauge. No barbed wire. If zebra are in the district the oval steel, 10 x 12, is the better. Government regulation spacing.

Droppers.—Leleshwa dropper, four to the panel, wired on (i.e. 12 ft. apart).

(The farmer responsible for this specification states that he has known zebra to tumble over and through such a fence without breaking it down.)

Small Paddock

Posts.—As above, 20 ft. apart, with three droppers to each panel.

Wires.—Five wires, two top and two bottom of plain steel, oval 11 x 13 gauge, with the middle one of barbed wire.

2—*Some Variants in Use in Kenya*

(*a*) Five wires, high tension steel, 12 x 14; spacing, 12 in. from ground and 9 in. apart. No barbed wire. Strainers 220 yds. apart, line posts 30 yds. apart, droppers 10 ft. On another farm where game is very plentiful (and timber) a rigid fence, with posts 4 yds. apart and no droppers, is preferred.

(*b*) Five steel wires, the top one plain, then two barbed and the lower two plain (10 x 12 oval). Strainers the length of a coil of plain wire (about 920 yards) apart. The wires are fastened at each end, cut in the middle, strained up with a patent strainer and joined. Wire droppers. Posts 20 yds. apart.

(*c*) Five steel wire, all plain; two top of 10 x 12 and three bottom wires of 12 x 14. Posts 15 yds. apart, strainers 220 yds. apart. Heartwood cedar droppers 9 ft. apart.

(*d*) Five steel wires; top and bottom wires plain 10 x 12, and the three middle ones of barbed 12½ gauge, four points every 3 in. Strainers spaced the length of a coil of barbed wire, i.e. about 410 yds. No. 16 binding wire used for tying on wooden droppers every 15 ft. Line posts every 30 yds.

(*e*) Four barbed wires only, spaced at 12 in. on steel standards every 11 yds.; six Leleshwa droppers per chain.

The great difference in the spacing of strainers, posts and droppers is remarkable.

A common spacing for cattle fences is five wires at 7 in., 8 in., 9 in., 12 in., and 12 in., i.e. above ground level 7 in., 15 in., 24 in., 36 in., and 48 in. Metal standards and droppers to fit these distances can be obtained in Nairobi.

3—*New South Wales Cattle and Sheep Fence*

Posts.—5 ft. 2 in. long, 22 in. in ground, 66 ft. apart, bored for threading wires at 6 in. 11 in., 21 in. and 28 in. above ground level. Tops bored to take wire ties for fastening a sixth strand of barbed wire at 40 in. above ground level.

Wires.—Five No. 8 gauge and one top strand of barbed wire.

Droppers.—Three per panel.

It will be noted that this fence is only 3 ft. 4 in. high, but it is claimed that it is high enough to prevent horses or cattle from reaching over owing to the barbed wire. Lincoln rams have been driven against it, only to find that the "spring" of the wide panels has sent them flying back.

At the present price of materials here, it is likely that this fence would cost £40 a mile to erect. More posts would be required on uneven land.

4—*Stock Fence in England*

The Ministry of Agriculture recommends No. 4 gauge at the top for heavy stock, with Nos. 5 or 6 lower down, and for lighter stock No. 6 on top and No. 8 for the lower wires. Spacing 6 in., 6 in., 7 in., 8 in., and 10 in., with strainers 300 yds. apart.

Calf Paddocks

The three lower wires should be spaced 6 in., 12 in. and 19 in. above ground level, as calves can crawl under anything higher than 6 in. from the ground. The height of the calf paddock fence might be the same as other cattle fences on the farm, for it may be necessary at times to use the paddock for adult stock, and it is probable that one or more sides will be against cattle paddocks.

Bull Paddocks

A suitable fence would have stouter posts and seven wires, No. 6 gauge, with the two top strands of barbed wire, or six wires and a stout top rail, not nailed but mortised in or wired on. Height of fence, 4 ft. 6 in.

A restive bull will often be kept quiet if thin sticks are threaded vertically in the wires and touching, so that he cannot see out. A hedge planted close to the outside of the fence will serve the same purpose.

Horse Paddocks

The owner of a well-known stud in Kenya expresses the opinion that the use of barbed wire can never be justified round a paddock for horses.

He suggests posts 15 ft. apart with four or five strands of plain wire. The closeness of the posts is for visibility. Posts further apart, with 2½ in. wooden droppers every 8 or 10 ft., would be more economical and would serve the same purpose.

Another breeder says he does not like wire, and if he could afford it would have posts and rails. He describes a suitable fence as having three strands of wire, evenly spaced up to 3 ft., and a top wooden rail at 4 ft. This must not be nailed on, as an end might come adrift and stake a horse galloping round.

One letter contains an instructive paragraph which must be quoted in full:—

"I also think it very necessary on every stud farm to have two paddocks with top rails. We have these. One is used to turn the foals out into when first weaned, and this also has a rail half way down. The youngsters soon get to know what a fence means, and later, when moved to a paddock without the top rail, they do not go into the wire. If you could see them charge at the fence when first turned out you would see how necessary it is to make the fence very *visible* at first. The other one here is used for turning out strange animals who are sent to us for various jobs, and about which we have not the knowledge as to whether they know a fence or not. Once a horse knows what a fence is, the only real necessity is to make it easily visible for him, and he will never go into it unless frightened or something of the sort.

"I think two good paddocks, with good top rails, are necessary, though costly. I tried both gum and wattle poles as top rails, and you need have no hesitation in saying that, unless very specially treated, they are useless and only rot. Seasoned sawn timber is the only thing to use. If you leave the gum or wattle poles to season you cannot get a nail into them, and they still rot when exposed to wind, rain and sun."

If blood horses are kept, the fence should be at least 4 ft. 6 in. high. Great care must be taken to see that there are no sharp points of wire on the inside. No stays or struts should project into the paddock. The top rail particularly should be smooth and all posts and rails trimmed to take off jagged splinters. Horses are notorious for finding points on which to tear themselves.

Sheep Fencing

Netting or woven wire fences are the best, but are expensive. It is usually reckoned that no netting or woven wire fence is complete without a strand of barbed wire above it, so fixed that animals cannot get their heads in between it and the top of the netting. This is to prevent them from reaching over and bearing it down.

For movable sheep fences, netting is easier to handle than woven wire and cheaper. Nettings can be obtained with three-ply selvedges top and bottom and also with one or two extra three-ply wires in the middle for straining the fence.

Nettings are made with 3 in. and 4 in. meshes, from 3 ft. to 3 ft. 6 in. in height, and from 17 to 12 gauge, in fifty-yard rolls.

There are many kinds of woven wire fences offered for sale, usually packed in shorter rolls.

If wire fences are made to protect crops from sheep, a seven-strand fence is recommended, with the lowest wire 2 in. to 3 in. from the ground, as lambs can crawl under a higher wire.

The New South Wales fence mentioned above is suitable for sheep.

The New Zealand Government recommends seven wires, the bottom four plain, spaced 5 in. apart, then one plain at 6 in. interval, and two barbed on top at 9 in. and 11 in. The top wire 3 ft. 10 in. high.

Pig Fencing

The pig always wants to get out if he can see out. Only the best and strongest pig netting is recommended. Netting similar to sheep netting, but stronger, can be obtained, giving heights of 2 ft. 6 in., 3 ft., and 3 ft. 6 in. There are also some excellent woven wire fence nettings on the market which are stronger than netting.

Any weakness in a pig fence will soon be found out. At the State Farm, Warren, Queensland, a cheap, effective fence for pigs under paddock conditions has been made on the principle of shutting out the view. The fence consists of 6 in. or 7 in. diameter posts, 39 in. out of the ground,

each post bored with two lines of three holes, 4 in. apart, at ground level, 18 in., and 3 ft. The top and middle pairs of wires strung through these holes are plain No. 8; the bottom pairs are barbed wire. Old 36 in. netting is wired on both sides, leaving a 4 in. space between, which is packed with dry grass. As the pigs cannot see out, they do not worry. The barbs prevent them from rooting underneath.

Unfortunately the kind of netting is not specified. One hesitates to recommend anything thinner than No. 16 gauge netting. There may be maize-growers who have old crib netting which would come in for this kind of fence. Where timber is plentiful, a palisade fence, with the posts sunk 18 in., is effective.

Poultry Fencing

As poultry fences often have to be moved it is advantageous to space three No. 9 gauge iron wires, one at ground level or just below it, one at 3 ft. and one at 6 ft., on which the poultry netting can be tied with black baling wire. It is then easy to take down. Hard steel wire is not recommended, as it is difficult to manage, but if the posts and wires are left to be re-hung with netting at a later date, steel is the best, as it does not slacken as easily as iron wire.

For young chicks the bottom 18 in. can be hung with half-inch mesh netting, tied to the lowest wire and an extra one slung at 18 in.

Where hawks are troublesome, a number of strands of No. 20 galvanized wire (obtainable in small lots) should be stretched over the tops of the runs.

Yards

In East Africa the average farmyard has to be much bigger than in Europe, to allow a team of sixteen oxen to swing round with a wagon or implement. The fence should be constructed of the best materials, whether it be posts and rails, or wires. It may often be the scene of a chase to catch a calf for branding, or an ox to be trained. Straining and corner posts should be massive. When it is fenced a Kei-apple hedge might be planted on the outside, and in a few years' time it will be ready to take the place of the fence. A strong hedge is easier on wagons and implements if they "brush", and is more visible.

Assembly Pens for Cattle

Where possible these should be of the massive post and rail order, about 4 ft. 6 in. high.

Posts.—9 in. to 10 in. diameter, 8 ft. long, 3 ft. in the ground, 7 ft. apart.

Rails.—Four or five smooth rails, well mortised in the posts.

Corner and Gate Posts.—12 in. diameter, 9 ft. long, 4 ft. in the ground, and well stayed. The inside of the fence must be well smoothed so that frightened animals cannot easily damage themselves.

If wire has to be used, the fence posts should be strong and spaced closely, 15 or 20 ft. apart, and plenty of stout wooden droppers wired on.

Gardens and Orchards

See also notes on hedges.

There are so many kinds of garden and orchard fences in use that an attempt to describe them would fill many pages.

If a handsome garden fence is desired, any of the well-known hardware firms can supply particulars and illustrations of fine and durable materials.

In dry, windy districts, a wall is excellent, as it does not compete with flowers and vegetables.

Barbed wire should be avoided unless it is placed high up, well out of the way of clothing and faces.

Fruit trees need plenty of air, and hedges should be kept low around orchards.

Espalier fences are best made of tall metal standards, with No. 9 or No. 10 gauge wire spaced every 9 in.

Fifty lb. rolls of 16 gauge steel wire can now be obtained in Nairobi for granadilla fences.

Vermin-proof Fences

These are very expensive; the cost of a leopard-proof fence would be prohibitive.

A good type of jackal-proof fence costs about £200 a mile. Those interested should obtain a small bulletin called "Vermin-proof and Other Fencing," by A. P. van der Merwe, published at 3d. by the Department of Agriculture, Pretoria, South Africa.

Fence Work to Protect Trees

Single trees can be protected by netting wired on to three posts round each tree. A wooden triangle at the top helps to keep them spaced.

Another useful guard is a piece of laced pole or batten fencing. Poles about 2 in. in diameter can be bored with $\frac{1}{4}$ in. holes at intervals and strung on wires, or battens can be wired together until the requisite length of fence is made. Two No. 12 or 14 gauge wires are used, and twisted a few times between every two battens or poles to keep them apart the desired distance. Lengths of light batten fencing on two or three flexible strand wires are useful for erecting temporary fences.

(*To be continued*)

Beekeeping for Beginners—Part II

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THE LIFE OF THE HIVE

The greater part of a hive consists of worker bees (Fig. 1). They are actually females but, modified by the conditions under which they have developed during the grub stage, they have become structurally adapted for their life of hard work. Yet when a colony has become queenless and is without the means of bringing on a young queen rapidly, some worker bees may develop their ovaries, and, after a couple of weeks, begin to lay eggs. These eggs develop only into males, since the laying workers do not mate, and fertilized eggs are necessary for the production of females.

FIG. 1
Queen, Drone and Worker Bees. (Actual size)

The duties of the worker bees are many, and under normal circumstances follow a definite schedule according to the age of the bees. For the first three days they are employed in cleaning up cells. Then they become nurse bees, and tend the young grubs or larvæ (Fig. 2). First they practice on the older grubs, and then are allowed to feed the young ones. After about two weeks as nurses they cease this and begin to secrete wax, becoming builders as well. The process of wax production is described below. Though worker bees may fly on occasion after they are a week old, they do not become active foragers until they are between two and three weeks old. They continue as foragers or hive guards for the rest of their life.

Among the interesting modifications which have increased the efficiency of the worker bee is the development of the hind leg for the purpose of pollen collecting. Part of the leg is flattened and on the inside furnished with rows of stiff bristles, which enable the bee to brush off the pollen which adheres to its body hairs after entering a flower in search of nectar. At the middle joint is a strong comb, which collects the pollen from the brushes into the joint, where it is compressed. The pill of compressed pollen is then transferred to the pollen baskets on the outer surface of the leg. These baskets are made of long incurved bristles, which enable the bee to carry those familiar loads upon its legs.

Next in numbers to the worker bees come the drones, or male bees. These are larger, more hairy, and with broad blunt bodies. They are easily distinguished from the workers by their large eyes, which

meet on the top of the head. Beyond the fact that they are males, and so available upon those few occasions when mating is called for, they do not appear to have any other purpose in the colony. They are without stings, and so cannot guard the hive. They lack those structural modifications which permit the workers to collect food, feed the young, or build comb. Those who mate, die in the process; the remainder are male ornaments of an Amazonian society.

FIG. 2
Development of the brood, showing egg, larva one day old, and fully fed larva on the fifth day. (Enlarged)

To find the queen the hive must be opened and a careful search made. She is much more difficult to locate here than in more temperate climates, owing to the increased nervousness of the colony. She can be distinguished from other bees by her long tapering abdomen. Her head and thorax are in size midway between drones and workers, and she is more uniformly yellow in colour than the others.

The young queen is fertilized during her nuptial flight, and on her return to the colony she does not leave again, unless to lead away a swarm, nor does she mate again. It is estimated that she lays up to one thousand eggs in a day during the height of the season, when mortality among the workers is at its greatest. Upon the death of the queen, by accident or old age, a new queen is brought on as rapidly as possible, and after the nuptial flight continues on in the same way.

The worker bees build the combs from wax, which they themselves secrete, and the cells are used as nurseries for the brood, as the larvæ are collectively termed. The queen, surrounded by her attendant workers, moves across the comb and deposits in each cell a small white egg. From this emerges a white, legless grub or larva, which is carefully fed by the nurse bees until it has grown almost to the size of the cell is occupies. The nurse bees then close the cell with a convex lid made of a mixture of wax and pollen which permits of a certain amount of ventilation. The grub spins a silken cocoon in which it pupates, resting quiescent in the cell while it reforms its structures into those of the adult bee. The cells in which drone brood develops are larger in diameter than those used for workers; while for queens, compound cells are constructed at the edge of a piece of comb (Fig. 3).

The time taken for the development of the brood depends on the kind of bee resulting, as shown by the following table (after Wedmore):—

Stage	Queen	Worker	Drone
	Days	*Days*	*Days*
Egg	3	3	3
Larva, to time of sealing ..	5	5	6
Larva spinning cocoon—Pupa	7	13	15
Total from laying of egg to emergence of perfect insect ..	15	21	24

The comb is used also by the bees for the purpose of food storage. Bees feed on nectar, pollen and water. Nectar is the sweet juices occurring in many flowers,

and the long tongue of the bee, as with many other different insects, has been developed for the purpose of reaching the nectaries of flowers. The nectar is carried back to the hive in the front portion of the worker's stomach, and is regurgitated into the cells. Here it loses water by evaporation, and undergoes changes arising from addition of ferments during transport by the bee. When sufficiently concentrated it is sealed over for future use. Pollen is also gathered from flowers and is carried back to the hives as loads, in the pollen baskets on the hind legs of the workers. It is an essential food for brood, and is given mixed with honey after the first four or five days. Prior to this the young brood is fed on a glandular secretion of the worker bee. Adult bees use honey as their main food.

Wax is secreted in the form of small scales, from patches of glands situated on the underside of the abdomen of the worker bee. These scales are removed by the hind legs and passed to the powerful jaws, for moulding to the required shape. Wax production demands the consumption of a considerable amount of food, the average estimate being about ten lb. of extra honey for each pound of wax produced.

In most parts of East Africa, the temperature does not fall so low that the bee colony becomes dormant, as in the European winters. Similarly, the food is available all the year, except in areas with hot, arid summers, where lack of water may reduce bee activity to a minimum, mainly by its effect on the vegetation. In general, it may be assumed that bees forage continuously and brood develops without a winter break. There are, however, periods during which the food supply is greatly increased, usually just prior to and for some weeks subsequent to the rains. In areas where the short and long rains are divided by a distinct dry period, a third period is noted. Widespread blossoming of trees and shrubs brings the worker bees to maximum

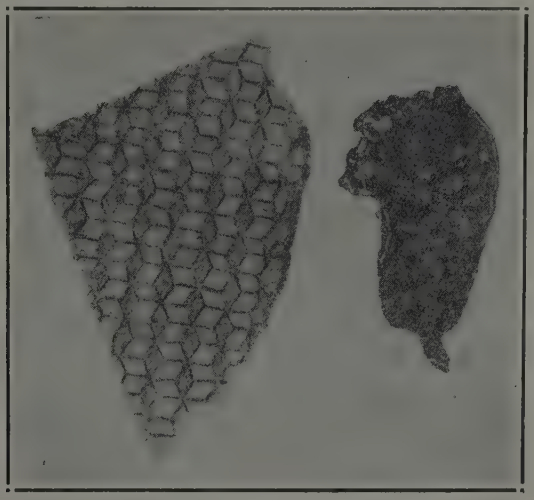

FIG. 3
Worker Comb (left) and Queen Cell (right). (Enlarged)

activity, which is maintained by successive waves of flowering plants. Quickly the brood within the hive produces a surplus of bees, and swarming results. The old queen leaves with a portion of workers and drones, leaving the hive under a new queen. Colonies appear to swarm regularly twice a year at least, and each time the hive is denuded of honey by the emigrants.

Further Operations

We return now to the new hive which has been set up and populated with a swarm of bees. After a preliminary inspection to see that all was well, it has been left alone for a month or two, and now consideration must be given to the next step.

First, however, there is the question of appliances which make for ease in handling bees. These are three in number: bee veil, smoker, and hive tool. A veil is almost essential in East Africa. It is a bag of mosquito-netting which rests over the hat and is long enough to be tucked securely inside the jacket collar or to fasten with tapes under the arms. The topee or terai worn beneath keeps the net well away from the face and bees are prevented from stinging the operator. The smoker consists of a small bellows and a tin containing suitable slow-burning material (corrugated cardboard or old sacking), by the combined action of which a stream of smoke can be directed as and where required. It is false economy to try makeshifts. Admittedly, on the one hand, the Bavarian beekeeper can produce enough smoke from his large, curved-stemmed pipe to calm his bees, and on the other hand a sting-immune native will drive his bees to one end of a long hive by blowing on a piece of smouldering bracket fungus; but a smoker is to be preferred. The third accessory is the hive tool. This is a steel bar, one end of which is narrowed and sharpened to a blunt edge like a screwdriver, while the other is broadened out, turned at right angles, and sharpened to a finer edge. It is used to prise apart the components of the hive and to scrape away the propolis, or tree gum, with which the bees seal up all cracks and gaps in the hive which are too small to permit of the passage of a bee. The East African bee is fond of coating the interior of a hive with propolis, with the result that super chambers are difficult to dislodge, and the frame tops require scraping before they can be slid along. An old and blunt wood chisel can be used as a hive tool.

Natives, without exception, will tell you that the only time to touch a beehive is at night when the bees are drowsy. The practice in temperate countries is to work during the day, when a large proportion of the population is away from the hive foraging for nectar. The writer favours the early morning, for although the bees may be less troublesome at night, it is essential to be able to see clearly what one is doing, and while the temperature remains low the bees are moderately tractable.

While manipulating a hive one should stand at the back to avoid any interference with foragers passing in and out of the hive. All actions should be slow and deliberate, avoiding all jerks and bangs. Wild striking at inquisitive bees flying around the face serves only to attract more bees. Avoid squashing bees when moving frames or replacing super chambers by driving them out of the way by a judicious use of the smoker.

Having got the smoker working, and with the hive tool to hand on a box conveniently near the hive, remove the lid, and, gently smoking, roll back the inner cover, and so expose the tops of the

frames. It will usually be found that the lugs of the frames are stuck together with propolis, and this must be loosened with the hive tool. Remove in turn the end frames to see if they are being used for brood or for honey storage. If either of them is untouched, examine the adjacent frames until the limits of the colony's workings are determined. When only four or five frames are in occupation, it follows that the colony is not sufficiently developed to produce surplus honey, and the hive should be closed up again and left. If, as may happen, the colony is not large enough to utilize the whole brood chamber, but indicates by considerable stores of honey within the chamber that the needs of the hive are more than satisfied, one or more empty frames may be removed and their place taken by a dummy board. This is a piece of wood cut to the dimensions of a frame, which is slipped into the chamber to act as a second wall and prevent the bees bridging with comb the space between the last frame and the true wall, as happens if less than ten frames are used. Restriction of brood space requires thought; on the one hand sufficient space has to be allowed for the building up of a vigorous colony, and on the other hand it is desirable that the bees be forced to store their surplus honey in the super chamber.

When it is found that the colony is spread well over the brood nest, then the wire queen-excluder in its frame is placed over the brood chamber and the super chamber placed on top, followed by inner cover and roof as before. It is advisable to see that the frames of the super chamber run in the same direction as those of the brood chamber, to facilitate ventilation and the movement of the workers.

The super chamber is fitted with frames in a similar manner to that described above for the brood chamber. The frames may be fitted either with complete sheets of wax foundation or with narrow strips fastened to the top of the frame, known as starters. When it is proposed to extract the honey from the frames by machine the use of wired frame is recommended. If there is any likelihood of the honey being eaten in the comb, then, of course, wire cannot be used. The use of starters is only recommended where foundation comb is unobtainable or expensive to purchase, as it diverts both time and honey to wax production, with consequent reduction of the honey crop.

The rate at which frames in the super are filled with honey will depend on the size of the colony and on the state of the surrounding vegetation. Should the super be found to be filling rapidly, a second chamber should be assembled and inserted between the queen-excluder and the initial super. The bees will continue to work on the first super until it is completed before giving much attention to the new one. Honeycomb should not be removed from the hives until the cells have been capped with wax by the bees. Until this time the honey is immature and not at its best. The comb may be cut out and eaten as such, or the honey extracted and the empty comb returned to the hive for refilling. The cappings of the cells are shaved off by means of a long sharp knife and the frame stood up in a warm place to allow the honey to run out of the cells. Special knives are sold for uncapping, but are not essential when the hives are few in number. Removing the honey by dripping is a slow process, and as the number of frames to be treated increases a mechanical extractor becomes necessary. This consists of a tank in which frames are placed after uncapping and there rotated at great speed, the honey being drawn out by centrifugal force on the same principle as is employed in a cream separator.

When removing honeycomb from a hive it should be kept in mind that one is taking the surplus stores of the colony. At a time when flowers are numerous and weather conditions favourable for foraging, most of the honey in the hive may be regarded as surplus, in so far as the workers will have little difficulty in obtaining supplies in excess of their daily requirements. As the less favourable season approaches, due to either low temperatures or low humidities, according to the situation, so does the rate of replacement, and hence the potential surplus, decrease.

Pests

Bees have enemies with which the beekeeper will have no desire to share the fruits of his labour. The ant-proof stand described in Part I will do much to keep the hive free from intruders such as white ants, true ants, lizards, toads and mice. A neglected hive, usually with a weakened colony, tends to become infested with caterpillars of the wax moth. These caterpillars feed on the comb and pollen stores, weakening the structure and spoiling the appearance of the combs. Black or brown shiny-backed beetles of the family Cetoniidae are also to be found in neglected hives. The most serious pest of hives is undoubtedly the honey badger or ratel. This beast is the size of a large cat, with dark fur and a distinctive light stripe down the middle of its back. The ratel has exceedingly strong fore limbs, with which it can tear open beehives as well as dig under the walls of chicken runs. The native suspends his log hives by long poles or ropes from the branches of tall trees in areas where the ratel is common. In similar areas, European hives must be anchored down by at least one strand of fencing wire attached to pegs in the ground or wrapped around two boulders, otherwise the ratel can easily push over the hive and destroy the contents.

Books

These few notes are intended only for the beginner. Having arrived so far on the road, he will either give up the pursuit entirely as uncongenial, or become an enthusiast. In the latter case, unless the guidance of an experienced beekeeper be at hand, the possession of one or more reference books is advisable. There are a large number of books on beekeeping, most of which are good; in mentioning two only, the writer is in no way ruling out the rest, but indicates those of his own collection which have proved of most practical value. They are *A Manual of Beekeeping* by E. B. Wedmore (Arnold, London), and *The ABC and XYZ of Bee Culture* by A. I. and E. R. Root (Root, Medina, Ohio). For those interested in the anatomy and physiology of the bee, Dr. Fritz Leuenberger's *Die Biene*, or its French edition *Les Abeilles*, is invaluable. Much may be gleaned from the catalogues of British manufacturers of beekeeping supplies, who are mostly beekeepers themselves and ever willing to advise and assist the beekeeper abroad in his problems.

Experimental Work on Pastures in the Trans Nzoia District, Kenya Colony, 1935-36

By M. HALCROW, *B.Sc. (Edin.), Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Department of Agriculture, Kenya Colony.*

In many parts of Kenya, including the arable or mixed farming areas, the natural veldt grasses are often coarse and of rather low carrying capacity. The species present are the survivors of the unfavourable treatment which has been accorded to the pasturage by irregular grazing and by the frequent destruction of the herbage in the dry seasons by grass fires, which cause the more delicate (and usually more palatable) species to disappear.

Accordingly the improvement of the pasturage in areas such as the Trans Nzoia can more readily be achieved by ploughing up the existing pasturage and planting desirable indigenous or exotic species than by means of controlled intensive grazing on the natural veldt. Alternatively, the arable land may be left to fall back to "couches" (*Cynodon* sp. and *Digitaria scalarum*), but this means of obtaining good pasturage is slower.

In April, 1935, following preliminary observational trials carried out for four years with a great number of grasses and legumes on small plots, large plots were laid down on a farm on sandy loam soil near Kitale to test the carrying capacity, palatability, and resistance to drought of various grasses and mixtures. The farm on which the trials were planted (now owned by Dr. Ganz) is at an altitude of about 6,100 feet, and the average rainfall is about 48 inches.

The plots were planted with the following plants or seeds mixtures:—

Plot No.

1 Rhodes Grass (Australian Strain) at 20 lb. per acre.

2 *Paspalum dilatatum* at 20 lb. per acre.

3 Kikuyu Grass Roots.

4 Kikuyu Grass Roots and Korean Lespedeza at 1 lb. per acre.

5 Kikuyu Grass Roots.

6 Kikuyu Grass Roots and Burr clover, 1 lb. per acre.

7 Kikuyu Grass Roots and Molasses Grass roots and seed.
Paspalum scrobiculatum (Roots).
Rhodes Grass, 2 lb. seed.
Korean Lespedeza.

8 Naivasha Star Grass (Roots).
Molasses Grass Seed and Roots.
Trifolium subrotundum, ½ lb.
Korean Lespedeza, 1 lb.
Paspalum dilatatum Roots.

9 Cocksfoot, 5 lb.
Phalaris tuberosa, 5 lb.
Wild Perennial Rye Grass, 5 lb.

10 *Brachiaria* spp. Roots.
Setaria spp. Seed, 1 lb., and Roots.
Amphilophis pertusa, seed, ¾ lb.
Themeda triandra Roots.

11 Perennial Rye Grass, 8 lb.
Cocksfoot, 5 lb.
Timothy, 2 lb.
Late Red Clover, 2 lb.
Birdsfoot Trefoil, 1 lb.

12 *Brachiaria* spp. Roots.
Setaria spp. Roots.
Molasses Grass Roots.
Korean Lespedeza Seed, 1 lb.

13 Cocksfoot, 5 lb.
Perennial Rye Grass, 5 lb.
Crested Dogstail, 6 lb.
Tall Oat Grass, 4 lb.
Birdsfoot Trefoil, 1 lb.

14 Planted in July 1935 :—
Rhodes Grass (Australian), 5 lb.
Paspalum dilatatum, 5 lb.
Tall Oat Grass, 1 lb.
Molasses Grass, 1 lb.
Lucerne (Provence), 2 lb.

During 1936 the paddock was heavily grazed by animals which had free range

over the plots. When observations were taken in January, 1937, the first thing that was obvious was that certain plots had been grazed down to a far greater extent than others. Outstanding in this respect was *Paspalum dilatatum*, which formed a magnificent green sward which had been grazed absolutely flat.

Observations on the mixed leys brought out the fact that cattle select *Paspalum* in preference to all other grasses. Australian Rhodes grass comes a good second from the point of view of palatability. Then comes Molasses grass (*Melinis minutiflora*), which had tended to spread into neighbouring plots and to oust such species as Kikuyu grass and Rhodes grass. Molasses grass is evidently very palatable; it has been heavily grazed, and it forms a fine drought-resistant cover. The Kikuyu grass plots had not attracted the cattle as much as one would expect. Nevertheless, the grass had made a splendid cover, though not so good as the three species already mentioned. The English mixtures had not stood up to the conditions; during the dry weather the plots appear as bare red land with scattered tufts of burned-up herbage.

The leguminous constituents of the various mixtures had disappeared almost completely.

It is hoped that it will be possible during 1937 to graze the different plots individually to assess their carrying capacity and their reaction to severe trampling.

A Comparison of the Carrying Capacity of Natural Veldt and Kikuyu Grass Paddocks

At the Experiment Station, Kitale, four one-acre paddocks, two of them Kikuyu grass and two natural veldt, have been grazed in rotation since 1933. During 1935 and up to September, 1936, these four paddocks, together with a reserve of 1½ acres, have carried a small milk herd of five cows and in-calf heifers. From April, 1936, till the end of the year very careful grazing records were kept. These may be summarized briefly as follows:—

	Paddock No. 1	2	3	4
	Kikuyu		Veldt	
	Days			
7th April–30th April ..	7	6	5	6
7th May–2nd June ..	7	7	7	6
3rd June–23rd June ..	5	5	5	6
8th July–11th Aug. ..	11	10	6	8
25th Aug.–5th Oct. ..	12	11	9	10
19th Oct.–1st Dec. ..	9	13	10	13
Total ..	51	52	42	49

During intervening periods the stock grazed in the reserve paddock. It seems from these figures that but for a flush during the July-August period, which corresponded with the heaviest rainfall of the year, the Kikuyu paddocks had only a very slightly higher carrying capacity than the natural veldt paddocks. The rainfall during the year (64 inches) was much above average, a fact which possibly masked any differences that might be expected on account of the relative ability of the paddocks to withstand drought. There did not appear to be any correlation between these figures and the milk yields. On these figures it seems that the natural grasses in the Trans Nzoia not only stand comparison with Kikuyu grass but that they may have the added advantage of improving as they become older. However, it may be expected that different results will be given in a drier year. Further, it must be noted that the veldt grass was not entirely "unimproved" as it had been intensively grazed by cattle, which received supplementary

feeding during the dry seasons, for three and a half years previously.

The Effect of Various Artificial Fertilizers on Intensively Grazed Kikuyu Grass Paddocks

During the past four years two series of four quarter-acre strips of Kikuyu grass have been treated as follows:—

Paddock No. 1

Plot No.

1 Control: no fertilizers.
2 Sulphate of Ammonia 200 lb. per acre plus 330 lb. Rock Phosphate per acre in 1933 and in subsequent years half these amounts.
3 Sulphate of Ammonia 200 lb. per acre plus Sulphate of Potash 80 lb. per acre in 1933 and half these amounts in subsequent years.
4 Rock Phospate plus Sulphate of Potash (as above).

Paddock No. 2

5 Complete Fertilizers: Sulphate of Ammonia 200 lb. per acre, Rock Phosphate 330 lb., Sulphate of Potash 80 lb. in 1933; with half these amounts in subsequent years.
6 Sulphate of Ammonia: 200 lb. per acre in 1933 and 100 lb. per acre in subsequent years.
7 Rock Phosphate: 330 lb. per acre in 1933 and 165 lb. per acre in subsequent years.
8 Limestone 2 tons in 1933, ½ ton per acre in 1935.

It has always been impossible to say definitely which plots were best—though the control plot in Paddock 1 has always appeared worst—so there was started a routine system of sampling random square yards of the green grass cut immediately before the paddocks were due for grazing. Throughout the season every plot was examined four times, and on each occasion five samples were taken, making a total of twenty square yard cuts in each quarter-acre plot. Comparisons were based on the weight of green grass per sample. Taking the control plots as 100 per cent, the following results were obtained:—

Paddock No. 1

	Per cent of Control
Plot 1: Control (no treatment) ..	100
Plot 2: Without Potash	133·5
Plot 3: Without Phosphate ..	175·9
Plot 4: Without Nitrogen	175·3
Paddock No. 2	
Plot 5: Complete Artificials ..	118·3
Plot 6: Nitrogen only	104·6
Plot 7: Phosphate only	90·9
Plot 8: Lime only	100

Unfortunately the figures for the two paddocks are not comparable on account of their being cut at different times. The plots within any one paddock are comparable. It will be seen that potash has given the biggest increase in weight of herbage.

Similar sample cuts were made after the paddocks had been grazed; the figures which were obtained seem to indicate that the stock prefer the phosphated and limed plots.

This work is merely tentative at the moment, but it is hoped that more accurate determinations will be possible in the future.

Small Trial Plots of Grasses and Legumes

One hundred and twenty-five trial plots of grasses and legumes were established on the Experimental Station at Kitale in 1934. Fifty-nine plots contain various tropical and temperate grasses (genera, species and strains), while sixty-six contain various legumes, mostly imported clovers.

Observations on the grasses indicate that, from the point of view of bulk of green material produced, the tropical and sub-tropical grasses are to be preferred to those from temperate regions.

The best and most leafy growth has been made by Rhodes grass (*Chloris gayana*) (local), *Cynodon* sp. (local), *Setaria trinervia* (local leafy selection), *Brachiaria brizantha,* Molasses grass

(*Melinis minutiflora*), Rhodes grass (Australian strain), *Phalaris tuberosa, Paspalum dilatatum* and *Amphilophis pertusa.* With the exception of *Phalaris tuberosa,* all these grasses have flowered freely, and all appear well suited to the Kitale conditions. They seem resistant to drought to a varying degree; in this respect *Paspalum dilatatum* is outstanding.

The wiry stems of the *Cynodon* sp., the rather soft foliage of the Molasses grass and *Phalaris tuberosa,* and the low, flat growth of the *Paspalum dilatatum* make these grasses difficult to cut and consequently unsuitable as hay. For mowing, the Rhodes grass, *Setaria trinervia, Brachiaria brizantha,* and *Amphilophis pertusa* are admirable.

Kikuyu grass (*Pennisetum clandestinum*) grows only moderately, and though it covers the ground well it does not have the healthy vigorous appearance so characteristic of it in some parts of the Colony where the altitude is greater, the temperature cooler and evaporation less intense.

The imported grasses, such as Perennial Rye grass (*Lolium perenne*), Cocksfoot (*Dactylis glomerata*), Tall Oat grass (*Arrhenatherum avenaceum*), Crested Dogstail (*Cynosurus cristatus*) and the Fescues, looked moderately healthy during the wet weather and flowered sporadically, but they made little growth, and were severely burned during the dry weather. Nevertheless they survived, with the exception of Timothy (*Phleum pratense*), which died out completely. The Tall Oat grass looked best, but it could not be said to compare with even the poorest of the local grasses.

In general the legumes are doing badly; many species have completely died out, such as *Trifolium incarnatum* (Crimson Clover), *Trifolium fragiferum* (Strawberry Clover), and others. The various strains of English Red Clover (*Trifolium pratense*) have flowered and grown well in patches, but the plots are generally poor. *Trifolium repens* strains have grown well or fairly well, the best being New Zealand White Clover. None of these, however, is as good as the Kenya wild white clover (*Trifolium Johnstoni*), which made extremely good growth and spread to the neighbouring plots. The Dwalganup Early variety of *Trifolium subterraneum* has done well, making a splendid cover, 6 to 8 inches high. Persian or Shaftal clover (*T. resupinatum*) also has made very good growth, and looks as if it may be useful. The last three species, together with Montgomery Red Clover (*T. pratense*), have distinct possibilities for the Trans Nzoia. Black Medick, Danish (*Medicago lupulina*) and *M. denticulata* (Burr Clover) have grown and flowered well and made a good cover, the former being the better. Both crops, however, fail to suppress weeds completely. Weed growth is also prevalent in the plots of *Lespedeza* species. These spread rapidly and seed profusely, but they rarely make the luxuriant growth for which they are noted in parts of the United States of America. The Early Hunter River and Tagerim varieties of lucerne have grown moderately well and attain a height of 12 to 20 inches. They flower freely, but they are susceptible to leaf disease in the wet weather.

Compost-Making in Uganda

By A. L. STEPHENS, *Plantation Manager, Serere, Department of Agriculture, Uganda Protectorate.*

INTRODUCTION

The beneficial effects of organic matter on soil structure, water-holding capacity, and as a food for micro-organisms have long been recognized. Controversy has, however, raged as to the best method of achieving the upkeep of the humus content of the soil. Farmyard manure, green manures, and various artificial composts have, all in their turn, been advocated. The very fact that differences of opinion exist shows very clearly that not one of these methods is ideal; the success or failure of their application depends entirely on local conditions. It is usually submitted that the average small farmer cannot produce sufficient farmyard manure to keep his land in good heart. Green manuring, under ideal climatic conditions, would provide a complete solution to the problem. In farming the percentage of ideal years is very small, and in practice green manuring often fails, especially in the tropics.

COMPOSTING

For many years compost heaps have been a feature of gardening in England. This applies mainly to market gardening and horticulture in or near the towns where farmyard manure is unobtainable. In general, the history of compost-making may be said to have consisted of a number of waves caused by periodic publication of composting methods. The most notable crests of recent years have been due to the descriptions of the Adco and Indore methods. During the years 1925 to 1929 the Adco process was tried in Uganda, and the difficulty of uneven decomposition, mentioned by Beckley [1] in the first article of this series, was encountered.

The difficulty was overcome, either by frequent turning or by chaffing the vegetable matter used. The initial cost of the starter, plus that of the extra labour involved, made the process uneconomic on European estates and impracticable in peasant agriculture. On coffee the results produced by a mulch or by a three-ton application of cotton seed far exceeded those of the application of the organic manure. All the earlier composting methods aimed at the production of a fairly long material resembling farmyard manure, thus differing from the results of the market gardeners' efforts and from those produced by the Indore method.

THE INDORE METHOD

After the publication of the Indore method by Howard and Wad [2] a further series of trials was started at Serere and Bukalasa. Howard states (p. 77) that "continuous supply of mixed vegetable wastes throughout the year, in a proper state of division, is the chief factor in the process." He goes on to say that "the ideal chemical composition of these materials should be such that, after the bedding stage, the carbon-nitrogen ratio is in the neighbourhood of 33 : 1." This could only be done at Indore (*a*) by cutting the cotton stalks as soon after the final pick as possible so as to secure the maximum number of leaves, (*b*) by growing an area of sunn hemp containing when withered as much as 2.3 per cent of nitrogen, and (*c*) by securing as much green weeds, groundnut residues and fallen leaves as possible for the mixture. At Indore, too, all woody materials, such as cotton stalks and the stems of sunn hemp and pigeon pea, were crushed by traffic into a fine state of division before composting. These

stipulations are at variance with the policy at Serere and in Uganda generally.

In the first place, it is extremely important that the close season for cotton should be enforced as rigidly as possible, as a measure of pest control. To that end there is legislation under which all cotton must be uprooted and burnt by a certain date which is gazetted each year. Although composting conditions would admittedly kill most pests, there remains the danger of the production of a large number of volunteer cotton plants during the preliminary carting and crushing by traffic. Secondly, the growing of a special legume for composting is, at the moment, hardly within the scope of the peasant farmer. Even at Serere the production of sunn hemp for composting would interfere with the normal working of the farm under its present rotation of cotton and food crops followed by grassland fallow. Finally, in the light soil areas of Uganda, where the loss of soil structure, followed by erosion, is such a real danger (especially in the cultivation of cotton), the native is advised to plant his cotton in contour lines and to ridge up the weeds between the lines to prevent wash. In view of these considerations, it was decided to begin composting trials at Serere with *lusenke* (*Imperata cylindrica*). This grass is present in abundance in most parts of the Eastern Province, is useless for grazing, and provides ample bedding during the dry season. It is therefore the material most readily available in the short grass areas should the native ever take up composting. In discussing the manufacture of compost from single materials, Howard advocates the use of a chaffcutter or alternatively crushing the material with a disc harrow prior to its use as bedding. On plantations under European supervision there is no doubt that such a pre-treatment could be carried out with advantage. Uganda, however, is almost entirely an area of peasant farming. The process must be modified in such a way that the native can reasonably be expected to carry it out effectively without supervision. The same principle has been observed in all our modifications of the process. All complications must be avoided, always bearing in mind that although it is extremely improbable that the native in this area could be persuaded to adopt the manufacture of compost at his present stage of development, yet, with the advance of education and the gradual infiltration of new ideas, he may eventually be in a position to take it up in its simplest form. At Serere therefore it was decided to rely solely on the trampling of the bedding by the cattle to bruise and break it to facilitate decomposition.

The Process

The measures used are the same as those of Indore, except that the mortar pan (*tagari*), with its awkward fractions, has been replaced by a wooden box of internal measurements 4 in. x 3 in. x 7 in. (15 boxes=1 *tagari*). At first, the published details were adhered to as strictly as possible, but it was soon found that decomposition in pits was extremely slow, particularly during rainy weather, and accordingly the work was carried out in heaps above ground level, as at Indore during the monsoon. When the details of the process were mastered, it was decided to aim at producing one ton per day, and the heap size was reduced to 16 ft. x 8 ft. x 2 ft., so that one heap could be fully charged each day. Such a heap consists of ten layers of two stretcher loads per layer. The quantities which follow, up to the completion of the heap, are as per layer; whilst the subsequent waterings are as per heap. In the morning five boxes of dung are removed from the shed, the remaining dung being spread over the bedding, together with eight boxes of dry

powdered urine earth. This mixture is then carted to the compost factory to form the first layer, over which is scattered one box of wood ashes and a further eight boxes of powdered urine earth. The slurry, made up of five boxes of dung and six boxes of a fortnight-old fungus material, is then sprinkled over the heap, using a small twig broom. This process is repeated with each of the ten layers, when the heap is complete. A little urine earth is sprinkled on top of the finished heap, followed by five tins of water. On the following morning ten tins of water are sprayed over the heap, and thereafter the waterings and turnings are according to the following table:—

TABLE I
TIME TABLE OF WATERING AND TURNING OF HEAP

Day		Water per Heap (in petrol tins—4 gallons) Dry Season	Rains
8	.. ..	10	5
15	1st turn ..	40	25
22	.. ..	10	5
29	2nd turn ..	35	20
36	.. ..	10	5
43	3rd turn ..	30	15
50	.. ..	10	5
57	4th turn ..	25	10
64	.. ..	10	5
71	5th turn ..	20	5
78	.. ..	10	5

The waterings during the rains vary according to the previous weeks' rainfall. One inch of rain on these heaps is equivalent to about 17 tins of water, and after large falls watering is unnecessary.

COSTS

The costs of compost manufacture, apart from pure wages, are governed by the distance of the water supply from the cattle shed, and by the availability of the supply of bedding. At Serere there is ample bedding close to the kraal, but the water supply is about a mile away. The bedding therefore has to be carted to the compost site close to the water. Thus, although these costs may be said to be peculiar to Serere conditions, they are given as a matter of interest in Table II.

Although it is admitted that our choice of a tough grass of low nitrogen status as a starting material is unfortunate, to say the least, yet it is material readily available to the native, and must be used. Decomposition is uniformly slow in the heaps up to the first turn, at which stage the grass is permeated with mycelium. Temperature changes, too, are very much slower than those recorded from Indore. There is no rapid rise during the first twelve hours, and at eighteen hours the average temperature of the middle of a heap is only about 50° C., rising to 56° C. after forty-eight hours, and 58° to 60° C. on the fourth day.

It is possible that the smaller heap has some effect in reducing the temperatures, but, as the heaps are quite close together and not in an exposed position, this effect should not be very great. The tendency is for the heap when first made to remain too open owing to the length and toughness of *lusenke*, much of the fungus inoculant being washed off the upper layers during the first two waterings. Later in the process the heaps seemed too compact for efficient aeration. Following these observations, the early waterings have since been reduced and the two extra turns have been added. The complete process takes about 120 days, instead of 90 as at Indore. The only modifications of the Indore process introduced up to the present therefore are:—

(*a*) Substitution of small box for the mortar pan;
(*b*) Reduction of size of heap;
(*c*) Waterings at weekly and turns at fortnightly intervals;
(*d*) Two extra turns;
(*e*) Reduction of watering to minimum;
(*f*) Use of single material instead of mixed wastes.

TABLE II—Costs of Serere Compost per Ton

Labour working a 7-hour day at a mean wage of 35 cents per day.*

Oxen working 3½-hour day at a cost of 12 cents per day.

Type of Work	Dry season Five months	Remainder of year
Cutting bedding	1 5/7 man days	1 5/7 man days
Cleaning out cattle shed, digging urine earth and re-bedding	1 6/7 man days	1 6/7 man days
Carting new bedding to shed and used bedding to heaps	1 5/7 man days 3 3/7 ox days	1 5/7 man days 3 3/7 ox days
Mixing compost and turning heaps	2 man days	2 man days
Carrying water and watering	4 man days	2 man days
Total {	11 2/7 man days 3 3/7 ox days	9 2/7 man days 3 3/7 ox days

Thus during the dry weather the cost is :—

	Sh.
11 2/7 man days at 35 cents ..	3·95
3 3/7 ox days at 12 cents.. ..	0·41
Total .. *Sh.*	4·36

During the remainder of the year the cost is less by 2 man days =70 cents or Sh. 3/66.

*(100 cents=one shillings)

The Result

Analytical data from a number of local composts are given in Table III:

TABLE III—Composts

Origin	% Moisture	Loss on Ignition	Carbon %	% N.	C/N. ratio
Serere Wet	9·1	10·3	5·97	0·43	13·9
Serere Dry	1·8	13·7	7·93	0·46	17·2
Serere 90 days	65·0	20·2	9·5	0·62	15·3
Serere 45 days ..	57·6	37·0	11·2	0·77	14·6
Serere S.H. 1	33·2	14·2	7·50	0·51	14·7
Serere S.H. 6	23·3	8·6	4·28	0·35	12·2
Mbarara	38·0	16·2	9·40	0·78	12·1
Bukalasa	57·0	23·5	13·64	0·77	17·7
Mean of 8 Uganda ..	—	—	—	0·586	14·7
Mean of 12 Indore ..	—	—	—	0·896	12·85

Apart from the fact that no local compost has been made up to the standard of that from Indore, the most notable feature of the results is the small loss on ignition, indicating a comparatively low content of humus. As Beckley [1] has already pointed out, the final product is mainly soil, and it is a waste of time and money to make and distribute soil. The high inorganic content of the product is undoubtedly due to the comparatively large amounts of urinated earth used in the manufacture, but the use of so much soil in the Indore process is not entirely on account of its lime content (the ash is much more valuable in keeping the heap sweet), but because it is a convenient vehicle for carting the starter (urine) to the heap and for the absorption and retention of the products of decomposition. The amount of soil could be reduced by adopting some other means of collecting the urine and by using it in the slurry. A cattle-shed floor sloping towards a mortar pan sunk to ground level might serve, and trials along these lines will be carried out. At the moment, the results of composting in Uganda do not justify its use by the native farmers, particularly as much better material may be obtained, with less labour, by bedding the cattle in covered kraals and storing the manure under the hoof, as results show in Table IV.

The compost produced at Serere, although poor as judged from analysis, has proved an excellent top dressing. In the light soil areas of the Protectorate as a whole, however, the use of such finely divided material is less effective in maintaining soil structure than the longer manure obtained from the kraal, although the former is more easily incorporated. The final and determining factor in favour of farmyard manure as opposed to compost, in an area of native agricultural production, is that of water supply. Many homesteads are situated at long distances from a reasonable supply, and water is essential in composting; but the moisture in the kraal is carried by the cattle at no inconvenience to the owner. Rain-made compost is practicable in areas of good rainfall distribution, but the main cattle areas in Uganda are on the light soils, where manure is most needed, and where long dry seasons are the rule.

TABLE IV—FARMYARD MANURE

Composition of Manure stored in different ways

Storage Method	Moisture %	Loss on Ignition	%N.	C/N.	% Soluble in 1:1 Hol. P_2O_5	% Soluble in 1:1 Hol. K_2O
(*c*) Rotted in pit with roof	40·8	20·5	1·05	11·3	0·079	0·030
(*c*) Rotted in pit, no roof	37·3	22·0	0·69	18·5	0·079	0·049
(*c*) Rotted in stack, no roof	47·7	27·6	1·24	12·9	0·170	1·38
(*c*) Rotted in stack with roof	39·3	51·3	2·15	13·9	0·445	—
(*c*) Rotted in pit with soil cover ..	60·4	40·6	1·29	18·3	0·328	—
(*a*) Stored under cattle	56·1	88·5	1·50	14·9	—	—
(*b*) Stored one year under cattle ..	65·1	47·0	1·17	15·3	—	—
(*b*) Stored one year under cattle; then exposed in heap two months ..	63·0	30·0	0·56	19·1	—	—

(*a*) This herd fed concentrates. *Lusenke* bedding.
(*b*) Bedded *lusenke*.
(*c*) Bedded elephant grass.

Summary

The method of compost manufacture at Serere is described, giving costs of production and analyses.

The only modifications from the Indore process are minor details in the direction of simplifying the process to bring it within the understanding of the peasant farmer.

Attention is drawn to the large amount of soil in the composts made to date, and the use of urine in the slurry is suggested.

Work on composting is continuing, but in the meantime the native farmer is advised to make and store manure in covered kraals under the animal.

Acknowledgments

The farmyard manure work at Bukalasa was carried out under the supervision of Mr. C. W. L. Fishlock (Agricultural Officer, Education). Analyses of farmyard manure and composts were by Dr. G. Griffith and Mr. E. Williams, whilst assistance has been given by Dr. W. S. Martin, Senior Chemist, in all aspects of the work.

REFERENCES

[1] Beckley, V. A.: "Composts and Composting," *East African Agricultural Journal,* Vol. II, pp. 384-386 and 470-473.

[2] Howard and Wad, Y. D.: *The Waste Products of Agriculture,* 1932.

A Note on the Yield of Mosaic-Diseased Cassava

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In the Eleventh Bulletin of the Agricultural Department of Nigeria (1936), Golding, in an article on cassava mosaic disease in Southern Nigeria, describes an investigation into its effect upon yield. It was shown that a stool of cassava with more than one main branch, and of which only one branch showed symptoms of mosaic in the early stages, yielded almost as heavily at maturity as a completely healthy plant. Compound stools of which all the main branches showed mosaic symptoms gave a greatly reduced yield.

This experiment has been repeated at Kizimbani Experiment Station, Zanzibar, with three local varieties of cassava, and its findings statistically confirmed. Twenty groups of five plants were chosen three months after sowing and marked. The five plants in each group were the following:—

1. *Partly diseased,* i.e. one of the two main branches showing symptoms of mosaic disease.

2. *Paired control,* i.e. a healthy plant of similar size and branching to the above.

3. *Wholly diseased,* i.e. with all branches showing symptoms of mosaic disease.

4. *Paired control* to 3.

5. *Random control,* i.e. one healthy plant in each row taken at random.

Nine months after planting the plants were harvested and the roots weighed. The class averages were:—

	Per Plant.
Partly diseased	5.60 lb.
Paired control	7.00 lb.
Wholly diseased	1.65 lb.
Paired control	5.35 lb.
Random control	7.10 lb.

Subsequent statistical analysis indicated that (at 1 per cent significance) the wholly diseased plants yield significantly less than all other types. There was no significant difference between the yield of a partly diseased plant and that of a healthy plant.

This would appear to indicate that, in commercial growing with a short-term cassava, rogueing, if continued beyond three months in the field, should be confined to those plants which are wholly infected; although care should be taken at harvest to obtain cuttings for subsequent planting only from entirely healthy plants.

It is to be observed, however, that it may be advantageous to rogue and replace by clean cuttings all plants showing even traces of mosaic up to some stage prior to three months after planting, and trials directed towards this end are in progress. It is also possible that, in the case of cassavas which normally are left in the field for periods of one year or more, rogueing might be continued with advantage for a longer period than is advisable with the earlier harvested types.

The Technique of Artificial Insemination in Cattle and Sheep

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During the last few years artificial insemination has been successfully applied to cattle and sheep in Russia, where the pioneering work on this subject was carried out. Its application to live-stock breeding has reached the stage where it has ceased to be experimental and is now of great practical importance for the improvement of live stock. For the last eighteen months the methods used for artificial insemination have been investigated at the Experimental Station, Naivasha, and it was found that as good results could be obtained with artificial insemination as with normal service. Recently the work has been extended to several farms in Kenya, and the results obtained so far indicate that the application of artificial insemination to cattle and sheep in Kenya may be of considerable value. Numerous inquiries about the possibilities and technique of artificial insemination have been received lately, and it is felt that there is a need for a brief description of the method. It was with this object in view that this paper has been written. The procedure, which is based on Russian methods (1933), has been fully substantiated by practically two years' work at Naivasha. The author has also made use of a recent publication on the subject by Dr. Walton (1936).

The practical application of artificial insemination to cattle and sheep presents no great difficulties once the procedure is mastered. Emphasis must, however, be laid on the necessity of paying full attention to details. Its utility to cattle and sheep breeding will depend on the farmer himself, by whom it must be applied. A full account of the results of present experiments will be published in due course. For the present it will suffice to say that it has been employed successfully on one sheep farm by the farmer himself, and that the results to date in cattle on two other farms, where it is also being carried out by the farmer with the help of native assistants, are satisfactory.

Any further information on the subject can be obtained from the Veterinary Research Officer, Experimental Station, Naivasha.

General Procedure

The general procedure consists of (1) the collection of sperm from a sire by the aid of the artificial vagina, (2) examination and dilution of the sperm, and (3) injection of the sperm into the cervix of the female. Every specimen of sperm collected must be examined for density and motility, and only specimens which show a high degree of motility can be used for insemination. The cow or ewe which is to be inseminated must be on "heat". Teaser males are used to pick out animals on heat.

The fertility of a sire must be thoroughly tested before he can be used for insemination. This is done by collecting several specimens of sperm with the artificial vagina, when the ability and keenness of the sire to mate can be noted. The amount of the sperm ejaculated is measured, a count of the number of sperm present is made, and the degree of motility is estimated. Smears are then made from the sperm and the percentage of abnormal sperm is estimated. Only sires which reach a certain standard in these estimations can be used for artificial insemina-

tion. The best test of all, however, is the ability of the sire to fertilize females. In the case of the bull that has been in use, his fertility may be estimated from the records of his services on normal, healthy cows with good breeding records. With sheep it is good practice to allow the ram to serve, say, 10 ewes, a month or so before the beginning of the breeding season, and see how he "settles" them.

Cleaning of Apparatus

The following applies to the apparatus used for both cattle and sheep.

Artificial Vagina.—When new and after use, the artificial vagina should be cleaned with hot water and washing soda with a bottle brush. It is then thoroughly rinsed with water and wiped out with 65 per cent alcohol. The swab holder is used for this purpose. The artificial vagina should be kept in a place free from dust.

Glassware.—This is also washed when new and after use with water and washing soda, thoroughly rinsed with water, wiped out with 65 per cent alcohol, and allowed to dry on clean blotting paper. Bottles and test tubes can be plugged with cotton-wool to keep out dust. Pipettes should be rinsed out immediately after use, as the sperm is difficult to remove once it has dried. The syringe and vulcanite nozzle when new and immediately after use should be rinsed out with cold water; 65 per cent alcohol is then taken up in the syringe and left there until ready for use. The alcohol is then washed out with clean boiled water, and the syringe and nozzle are then rinsed out two or three times with dilutor.

A list of the equipment for cattle and sheep is given at the end of this paper.

Artificial Insemination of Cattle

For the collection of sperm one requirement is a cow on heat—preferably an older cow which has been handled a lot and stands quietly. The cow should be tied to a post with a halter or with rope round the horns. The ground should be level and not slippery. No difficulty should be experienced in getting a bull to mount the cow, particularly once he has become accustomed to the procedure. The bull should be led up to the cow on a halter or with a pole attached to the ring. There should be sufficient space behind the cow to allow the bull to be moved round if he does not mount the cow at once. As Walton points out, "It is of great advantage if the same yard is used for all services and collections, so that the bull becomes thoroughly accustomed to the surroundings and when led to the yard anticipates 'service'."

Preparation of the Apparatus

If possible, a separate building should be kept solely for artificial insemination work. No disinfectants or strong smelling chemicals should be allowed in this building, as they have a harmful effect on the sperm. The apparatus should be laid out on a table covered with a clean cloth or sheets of blotting paper. The artificial vagina is swabbed with 65 per cent alcohol and when dry smeared with medicinal liquid paraffin. Water which has been heated to 45° C. (113° F.) is then filled into the cup end of the artificial vagina. The free end of the rubber lining is then folded back and tied in place with string.

The small glass bottle, into which about 2 ml. of medicinal paraffin is placed, is then inserted into the small end of the artificial vagina, and is held in place by the metal cup, which is screwed on. The correct distension of the artificial vagina is then obtained, either by blowing air into or by running out water through the tap.

A small quantity of medicinal paraffin is then poured into the artificial vagina to

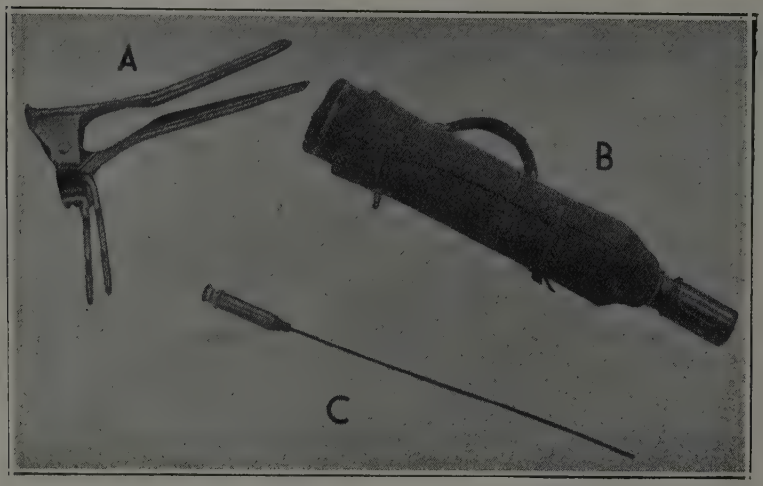


FIG. 1
Instruments for Cattle
A—Speculum
B—Artificial Vagina
C—Syringe

FIG. 2
Preparation of Artificial Vagina

FIG. 3
Artificial Vagina ready for use

lubricate it thoroughly. The temperature should be between 39° C. (102° F.) and 43° C. (109° F.). If it is too cold, more hot water must be added, and if it is too hot, it must be allowed to cool to the proper temperature before use. There is always a slight delay between filling the artificial vagina and collecting the sperm, and allowance must be made for this. The temperature, which should be read immediately before collection of the sperm, should lie between 38° C. (100° F.) and 42° C. (108° F.). The artificial vagina is now ready for use.

FIG. 4
Collection of Sperm

Collection of Semen

The collector stands on the off-side of the cow, holding the artificial vagina by the handle in the right hand. When the bull mounts the cow the artificial vagina is raised close to the flank of the cow at an angle corresponding to the probable line of erection of the penis. The penis is directed into the artificial vagina with the left hand, which grasps the sheath. The penis should not be touched by the hand, as this may cause retraction. When the penis enters the artificial vagina the bull thrusts vigorously forward and upward and ejaculates into the artificial vagina. Sometimes this may not happen immediately the penis enters the artificial vagina, and occasionally a bull will mount the cow two or three times before ejaculation occurs. A bull does not ejaculate unless he has this final upward thrust. When the bull has ejaculated he dismounts from the cow. The artificial vagina should be tilted with the cup end lower than the open end, so that the sperm does not run out. It should be held in position at the end of the sheath for a moment to catch any final drops of sperm.

Examination of the Sperm

The cup at the end of the artificial vagina is now unscrewed and the bottle containing the sperm removed. The sperm must not at any time be exposed to the sun, as this has a harmful effect. A normal ejaculation, which amounts to about 5 ml., is a thick, milky-white fluid containing living spermatozoa. Usually, the whiter and thicker the specimen the more numerous are the spermatozoa it contains. A less dense specimen is more transparent and of a bluish-white colour. Movement of the sperm can very often be detected by the naked eye. Every specimen of

sperm, however, should be examined microscopically. This is done by placing a small drop of sperm on a cover slip with a pipette and inverting a hollow-ground slide over the cover slip. The slide is then turned over and placed on the microscope. If cover slips and hollow-ground slides are not available, a drop of sperm can be placed on an ordinary slide and a drop of medicinal paraffin placed on the sperm to prevent it drying up. A good specimen of sperm should show very active movement; in a very dense specimen this is seen in the form of characteristic turbulent wave movements. The sperm should be examined immediately after collection. If this examination is delayed the fall in temperature may reduce the activity of the sperm.

FIG. 5
Ready for insemination

FIG. 6
Injection of sperm into cervix

Dilution of the Sperm.

Whether or not dilution is required depends on the number of cows to be inseminated. Bull sperm can be diluted safely with the addition of up to three times its volume of dilutor.

The sperm is measured and transferred to a test tube, and the appropriate amount of dilutor added (i.e. an equal volume, or two or three volumes of dilutor) drop by drop, and the two mixed by gently inverting the tube several times. The syringe and nozzle is rinsed out two or three times with the dilutor and the diluted sperm taken up.

Selection of Cows for Insemination

Cows in Kenya have a shorter heat period and heat is usually less intense than in cows in temperate climates. Heat may therefore be easily missed unless the bull is run with the cows. The best method of detecting a cow on heat is to run a vasectomized bull with the herd, or to put this bull with the herd twice a day, morning and evening. Such a bull will serve cows normally, but cannot impregnate them.

Insemination

The cow is secured in a milking bail and the legs tied if necessary. The vulvar region is cleaned with a sponge soaked in water. The sponge is then squeezed out and the vulva dried. A disinfectant must not be used for this purpose.

The speculum is now introduced by an assistant, with the handle held to one side. the speculum is then turned round and opened, and moved about until the cervix is exposed. The tip of the syringe nozzle

is next introduced about 1½ cm. into the cervix, and 1 ml. of sperm is slowly injected, so that all of the sperm remains in the cervix. The syringe is then withdrawn, followed by the speculum.

If another cow is to be inseminated the nozzle is disinfected with a cotton-wool swab soaked in 65 per cent alcohol and dried with a dry swab. This is repeated before each cow is inseminated.

Storage of Sperm

Experiments on the storage of sperm are still in progress, and the author is not yet in a position to recommend a standard method. The following method has, however, been used successfully: The sperm is diluted with two volumes of dilutor and transferred to a small test tube. The tube is filled up with medicinal paraffin and a cork inserted. A thermos flask is prepared with water at a temperature of 10° C. (50° F.). Cotton-wool is placed in the flask, and the test tube is wrapped in cotton-wool and placed in the flask, which should be kept in a cool place. As little time as possible should be lost between collecting the sperm and placing it in the flask. When the sperm is to be used, the test tube is removed from the flask and allowed to stand at room temperature for about fifteen minutes. It is then examined microscopically for motility, and only specimens of sperm which show a high degree of motility, comparable with those of a newly collected specimen, can be used. Sperm treated in this way has retained its fertility for about two days.

Artificial Insemination of Sheep

As an aid to the collection of sperm, a ewe on heat is required. A quiet ewe that is accustomed to being handled should be chosen. The ewe should be prevented from moving about by an assistant who holds her by the shoulders and neck.

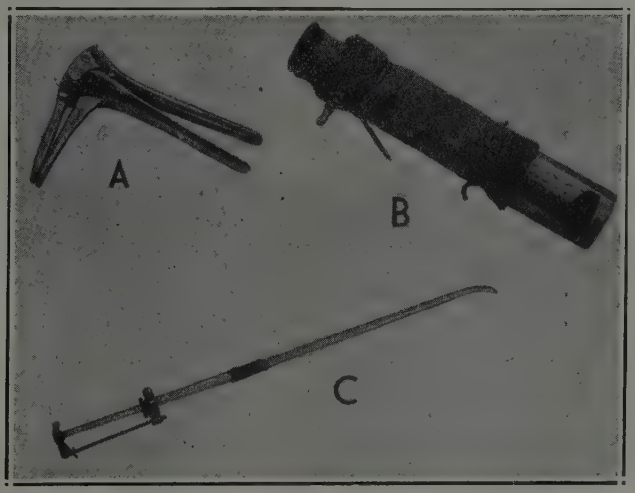


Fig. 7
Instruments for Sheep
A—Speculum
B—Artificial vagina
C—Syringe

The ram should also be quiet and easily handled. Young rams are often wild, and though sexually virile pay no attention to a ewe on heat, particularly in strange surroundings. If such rams are handled frequently and are exercised on a halter they will soon settle down. Young rams that have not served before should be allowed to serve two or three ewes before sperm is collected with the artificial vagina. As with the bull, it is an advantage to collect sperm always in the one place or building in order that the ram may become accustomed to his surroundings. When the ewe and the collector are in position, the ram should be led up to the ewe and he should mount her almost immediately. A second collection can be made after half an hour or so.

Preparation of the Artificial Vagina

This is done in the same way as with the bull artificial vagina. The correct distension, which is learnt by experience, is obtained by means of the tap on the side of the artificial vagina. The pressure required varies from ram to ram. The correct temperature of the artificial vagina at the time of collection is from 38° C. (100° F.) to 42° C. (108° F.).

Collection of Sperm

The artificial vagina is held against the flank of the ewe, and when the ram mounts the penis is directed into the artificial vagina with the left hand applied to the sheath.

The penis must not be touched with the hand. When the penis enters the artificial vagina the ram should thrust upwards, and ejaculate sperm into the upper end of the artificial vagina or into the bottle. The artificial vagina is then held vertical to allow the sperm to run into the bottle. Some rams are slower than others in ejaculating, and some may mount the ewe two or three times before they have a final thrust and ejaculation.

Examination of Sperm

A normal ejaculation measures about 0.7 ml. (in the Merino), and is a thick, creamy-white fluid containing living spermatozoa. A drop of sperm is placed on a slide and covered with medicinal paraffin, and examined under the microscope. The motility should be very active, and the characteristic turbulent wave movements should be seen.

Dilution of Sperm

The sperm is measured with a pipette and transferred to a test tube. One ampoule of dilutor No. 1 is then mixed with one ampoule of dilutor No. 2. Seven volumes of the mixed dilutor is then added drop by drop to the sperm, and the two mixed by gently shaking the tube. The syringe is rinsed out two or three times with dilutor, and the diluted sperm is then taken up in the syringe.

Insemination

The ewe should be stood on a table or placed on a rail, 3½ to 4 ft. high. The speculum and syringe are disinfected with a cotton wool swab soaked in 65 per cent alcohol, and then dried with a dry swab.

The speculum is then inserted into the vagina with the left hand, with the flat side of the blades of the speculum vertical. It is then turned so that the handle points downwards, opened, and the cervix exposed. The tip of the syringe is inserted about 1 cm. into the cervix and 0.2 ml. of sperm injected.

The syringe and speculum are then withdrawn and disinfected before inseminating another ewe.

EQUIPMENT FOR ARTIFICIAL INSEMINATION

Cattle

1 artificial vagina, Cambridge pattern, bull size.
3 spare rubber sleeves for above.
4 spare cups for above.

FIG. 8
Artificial vagina held ready for collection of sperm

FIG. 9
Collection of sperm

FIG. 10
Introduction of speculum and syringe

FIG. 11
Injection of sperm into cervix

6 cow insemination syringes, 2 ml.
1 vulcanite nozzle, 18 in.
2 glass rods, 18 in. long, $\frac{1}{2}$ in. diameter, for smearing bull artificial vagina.
1 swab holder, 18 in. long, for cleaning artificial vagina.
1 bottle brush, 24 in. long.
1 speculum, Polansky's, $14\frac{1}{2}$ in. blades.

Sheep

1 artificial vagina.
4 spare cups for artificial vagina.
1 ewe speculum.
1 ewe insemination syringe, with regulating screw and 1 spare syringe.
1 bottle brush, 9 in. long.
1 swab holder, 9 in. long.

General Equipment Required for both Cattle and Sheep

1 box (half gross) glass slides.
2 boxes square cover slips, $\frac{5}{8}$ in., No. 2.
1 head lamp with focussing attachment with battery.
2 chemical thermometers, range 10° to 110° C.
4 1 ml. pipettes, graduated in 1/10 down to up.
2 10 ml. pipettes, 1 ml. and 1/10 ml., graduated to up.
1 dozen rubber teats for pipettes.
2 dozen test tubes, i.e. fine pipettes.
2 pints medical paraffin.
1 microscope, with objectives $\frac{2}{3}$ in. and $\frac{1}{6}$ in., Abbe condenser and iris diaphragm.
2 thermos hard-glass flasks.
1 roll cotton-wool.
1 dozen glass containers to take sperm storage tube.
1 chemical thermometer, 5° to 50° C.
2 dozen Pyrex glass sperm tubes.

The approximate cost of the equipment for cattle is £28-8-0 and for sheep £22-16-6. The above equipment is obtainable from the Holborn Surgical Instrument Co., Ltd., 26 Thavies Inn, Holborn Circus, London, E.C.1.

REFERENCES

"The Technique of Artificial Insemination" (1933): Imperial Bureau of Animal Genetics, University of Edinburgh.

"Notes on Artificial Insemination of Sheep, Cattle and Horses" (1936), A. Walton: Holborn Surgical Instrument Co., Ltd.

Mutton Sheep in Kenya

By R. S. BALL, *M.A., Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Department of Agriculture, Kenya Colony*

There are large areas in the country that are highly suited for the raising of sheep for the mutton and lamb trade. It is probable that any extension of the industry likely to occur will be predominantly in the arable districts, where use can be made either of reverted arable lands and improved grazing, or arable crops for finishing fat lambs and hoggets. The existing ranching areas will become devoted more exclusively to wool production.

The chief sheep districts of the country at the present time are situated in the high-altitude, moist, red oat grass areas, such as Molo, Mau Summit, the Aberdares, and Kinangop, and in the dry areas such as Laikipia, which are essentially Merino country. In addition, there exists the large Naivasha area, where the exceptionally fine nature of the grass renders the rearing and fattening of sheep a profitable proposition.

The moist areas, where the growth of grass tends to be strong, have proved for the most part to be suited to the Kent or Romney Marsh sheep, with a sprinkling of other breeds, such as Corriedale. The drier areas, which after grazing tend to produce short volunteer grass such as *Digitaria* sp., provide excellent grazing for Merinos, which thrive best where keep has to be sought for and where the herbage is short and not tufted.

The supremacy of the Kent or Romney Marsh breed in the moister areas has been attributed to a variety of reasons—to a certain measure of resistance to fluke, to resistance to foot-rot, and also to the fact that this breed has proved very dominant in crossing for grading up from native sheep. It is difficult to understand why the Romney should show any greater resistance to fluke than other breeds, for although its natural home is a marsh, yet it is a salt-water one, in which fluke is not usually to be found. It would appear therefore that the prevalence of the breed in these areas is due primarily to dominance in crossing and to the fact that serious trouble from foot-rot is not usually experienced, provided the feet are properly looked after.

There are two distinct types of the breed in the country at the present time, namely the heavily woolled New Zealand type, which has been bred primarily to yield a heavy wool clip, and the English Kent type, which is predominantly a mutton sheep and is excellent for crossing with native or low-grade ewes, in order to put a larger frame on them. In England, where both types are prevalent, opinion on their relative merits is divided. There would appear to be little doubt that, where mutton is the primary object, the English Kent type is likely to prove the more satisfactory. Many of the English breeders who have used the New Zealand Romney are now changing back again to the English type for this reason. In this country, however, opinion must remain divided, since wool will be a deciding factor in the sheep policy.

The farmer who has facilities available for the production of fat lamb and mutton should aim at breeding a neat-framed sheep, maturing quickly (i.e. able to produce a fat lamb carcass, 80 lb. live weight, 40 lb. dressed carcass, at six months). If this is to be achieved, it is probable that it will be necessary to cross another breed with the Kent. The choice of a suitable type will probably rest with one of the

Down breeds, such as the Southdown, Ryeland, Suffolk, or Dorset Horn, since all of them are noted for quick maturity.

Of the Down breeds, the Southdown has probably proved one of the most satisfactory, more particularly for crossing with the Merino for ensuring quick maturity and mutton quality. The Suffolk has proved very satisfactory in England for crossing with the Kent breed, particularly in a country where foot-rot is liable to be troublesome. It is claimed that the Suffolk shows a certain amount of resistance to this disease owing to the fact that for generations it has been reared on arable land under wet conditions and has therefore developed a certain measure of resistance. The Ryeland suffers only from the drawback that it is a small sheep; and where size may be important, as in the case of grade ewes, it may be desirable to use a somewhat larger breed. The chief recommendation of the Dorset Horn is that the ewes will take the rams while suckling, and it is therefore possible to obtain two crops of lambs yearly. It is important to remember, however, that a breed of this nature requires very careful feeding and handling, since the strain on the ewes is naturally great, and due attention must be paid to the danger of loss of constitution.

One might elaborate further on the question of breeds, such as the use of the Border Leicester Cheviot (half-bred) ewe and a ram of one of the above breeds, for the production of mutton and lamb. It is, however, important to remember that the two chief types at present in the country are the Merino and the Romney; that they are predominantly the material from which the mutton sheep is produced, and that further improvements can be effected by suitable crosses.

Many people have naturally raised the question of the sacrifice of wool qualities when crossing is practised on a breed such as the Merino. Such sacrifice is of course entailed, but no serious hope would be entertained of entering any export meat market unless some crosses were made to give earlier maturity and improved quality.

It is doubtful also whether such crosses would thrive in the dry Merino country. They would probably be best sold as lambs to be finished in the wetter sheep areas or under arable conditions.

The Management of Mutton Sheep on the Mixed Farm

High Altitude Areas

The sheep has one great disadvantage as a unit in the mixed farming system, namely its readiness to deposit weed seeds on the land. Particularly is this true in the high-altitude moist areas; for seed of Kikuyu grass is very easily introduced into arable land, which is thus rendered difficult to clean when arable cultivation is again to be practised. For this reason, farmers in these areas have been reluctant to make use of their sheep in the farming system, and have confined them as much as possible to the veldt, with the result that lambs and hoggets are often slow to grow and do not finish readily. Those farmers, however, who have made use even of reverted arable land which is being allowed to rest from wheat on account of "Take-all" disease or for other reasons, have invariably found that the herbage has proved extremely beneficial to sheep, provided that weeds, such as "forget-me-not," that tend to stick in the wool, are kept under control. Further, the natural grassland, often containing a fair proportion of *Pennisetum schimperi*, is probably hard on the mouths of the ewes, although broken-mouthed sheep are rarely found in Kenya. If moved on to reverted arable lands, old and possibly lame sheep will

often do exceedingly well and yield another crop or two of lambs. It has already been pointed out, however, that the land will be difficult to clean when again required for arable cultivation. It is therefore necessary to go a stage further, and use a suitable mixture of forage crops or grasses, which will rest and recuperate the soil and also provide suitable grazing for sheep.

In the high-altitude moist areas, the English grasses and mixtures of them are likely to prove satisfactory for the purpose. Outstanding amongst these are Italian and Perennial Ryegrass, Cocksfoot, Danish Meadow Fescue, Birdsfoot Trefoil as a possible leguminous constituent, and the Australian grass, *Phalaris tuberosa*. Attempts are now being made to establish suitable mixtures of these grasses which will form a sufficiently close sward to prevent the germination of seeds of Kikuyu grass brought in by the sheep themselves. Where conditions permit of the establishment of permanent Kikuyu grass pastures they will yield an extremely valuable type of herbage, provided that during the rainy seasons the sheep either have access to ordinary veldt grazing or can be fed a certain amount of oat hay or similar dry material.

Kikuyu grass in a high state of productivity, as on a rich forest soil, should be capable of carrying about 4 to 5 sheep per acre, provided that the additional feeding material is available during the rainy periods. In making estimations of the carrying capacity of any area for sheep it is important to remember that the land can be easily "stained" and that mixed and rotational grazing is therefore essential. The fact that this is often difficult to practice on open unfenced veldt has contributed to the necessity for burning off the grass in order to keep it fresh and sweet for the sheep. Where grass-burning is a necessary practice it should be performed out of season as much as possible, so that there may be a growth of grass for the dry season.

In these high-altitude areas there is a rairly wide range of suitable arable crops, such as oats, rye, peas, vetches, all highly suitable as forage crops. These crops should be close-folded where possible, so as to minimize waste and ensure uniform consumption. An acre of a mixture of oats and vetches (oats 30 lb. per acre, vetches 25 lb. per acre) should provide keep for 100 sheep for about twelve days. Such forage crops should be used for flushing ewes before tupping, for fattening lambs and hoggets, and for old ewes who require careful attention. At no time, however, should sheep be confined entirely to arable crops. Unless they are either fed a certain amount of hay or allowed access to veldt grazing, digestive troubles are liable to occur from such excessively succulent material.

In all cases sheep should be herded in small flocks, segregated into the different classes—lambs, hoggets, ewes, etc. In this manner, strict control is ensured, grazing can be kept free of parasitic infections and foot troubles easily detected.

Intermediate Areas

The sheep industry, however, will probably not be confined in the future to the high-altitude and ranching areas, but will occupy a place on the mixed farm in the intermediate districts such as Njoro, Rongai Valley, etc. Although no great extension has taken place up to date in these areas, there is little doubt that high-grade sheep will thrive in spite of the warmer conditions. Much of the land is intermediate in character between the dry Merino areas and the wet Kent country, but owing to the strong growth of the grass and the necessity on the arable farm for restricting

the sheep's range of grazing, it is probable that the Kent and Kent crosses will prove to be the most suitable in these areas. Particularly at the lower limits it is desirable to keep a breed which is not heavily woolled; for this reason the English Kent type will probably prove the most suitable.

A farmer who wishes to start sheep farming in these comparatively new areas is probably best advised to commence with native or low-grade sheep, or alternatively to buy draft ewes, as the land may require a certain amount of cleaning up, and disease, such as scab, may be prevalent. The use of a pure-bred ram on such sheep will quickly provide the nucleus of a useful flock.

Management in these areas will consist largely of grazing over paddocked or reverted arable land, and the sheep will be used largely as followers to the dairy unit. A certain amount of silage should be available for the stock during the dry season, this being extremely palatable to sheep and particularly useful for fattening stock. Three pounds per head daily is a suitable amount for fattening sheep.

Young growing hoggets should not be allowed to get back in condition at any stage of their growth, otherwise it becomes almost impossible to obtain a neat, well-finished carcass; and sheep which have been stored for any length of time in this country become difficult to finish. Reverted arable lands in these areas often provide excellent sheep-grazing, a mixed herbage consisting of grasses such as *Cynodon* sp., *Digitaria* sp., and indigenous white clover being commonly found.

Farmers will often state that at present prices of mutton it is uneconomical to feed sheep on foods grown specially for the purpose. It should be pointed out, however, that many of these foods are very cheap at the present time. Moreover, although it is difficult to secure any extra price for well-finished mutton or lamb on the local market, if the possibilities of export are to be considered in the future, more intensive methods will be necessary. Further, there is little doubt that a certain amount of mortality amongst ewes and lambs could be prevented if old ewes or ewes suckling twins were given a small amount of hand-feeding. The cost of this on the mixed farm will be very low.

A few rations suited to sheep are appended:—

Concentrate Rations

Fattening lambs, up to 80 lb. (approximate live weight), through creep. One pound concentrate mixture:—

1 part maize meal,
½ part bran,
1 part pea meal or bean meal.

Or

1 part crushed oats,
1 part crushed barley,
½ part bran,
1½ parts pea or bean meal.

Fattening hoggets, 100 lb. live weight, 1 to 1½ lb. daily of mixture:—

1 part maize meal,
1 part crushed barley,
½ part bran,
½ part pea and bean meal.

Or

1 part crushed oats,
1½ parts crushed barley,
¼ part bran,
1 part pea or bean meal.

Ewes suckling twins and lambs (fed through creep), 1 lb. daily, according to condition:—

1 part oats,
1 part bran,
1 part barley,
½ part pea or bean meal.

All the above mixtures can be prepared with foods grown on the farm, or are obtainable at a low cost.

In addition, a complete mineral lick, containing a trace of Kerol, should be available for all classes of sheep. The Kerol is said to keep the sheep free from worms; thus frequent doses with violent drugs are not so necessary.

Individual Native Smallholdings

By N. V. ROUNCE, *C.D.A., A.I.C.T.A., Agricultural Officer, Department of Agriculture, Tanganyika Territory.*

Before embarking on a subject the scope of which is very wide but whose development is still in the very early stages, it should be pointed out that this article is the result of trials made and of arguments and considerations regarding it which have arisen departmentally. It is quite possible that some points which have been stressed may in time prove of less importance than others not even mentioned. The situation admits of much more study, but what follows, it is hoped, will indicate that enough light has already been thrown on the subject to allow of an advance towards the local goal.

The extent to which the native has a right to his land varies considerably, but the relinquishment of land when it has been fallow for a number of years is not unusual when there is another applicant, though this is not so in over-populated areas. Most important of all, on relinquishing the land, he neither loses nor gains by the bad or good agriculture that he may have practised on it. There are probably very few cases where the native authorities eject a man, for it is the form of agriculture practised by the native that is at root the cause of the insecure tenure. The aim is to replace it with a balanced "smallholding" agriculture which will secure the native to his land, wherein grounds for ejection will be based on the standard of cultivation undertaken.

The "smallholding" is in fact generally larger than the average native holding, but it is in one unit, contiguous to the house. Permanent tenure is the basis, together with the keeping and management of stock and its by-products. The native of East Africa is invariably secure in his land at the present time, providing he cultivates it, but it is necessary to secure the holder against himself and against mortgages, persuading him to follow practices which obviate shifting cultivation.

The last section of "Tenure of Native Land in East Africa" by Liversage (*East African Agricultural Journal,* Vol. I, No. 5) gives some idea of the type of land tenure which it is thought may be suitable to the East African. Liversage stresses the importance of tackling the problem before evolution is allowed to proceed too far, and suggests that the worst dangers of indebtedness and the consequent development of a parasitic landlord class might be avoided by making the mortgaging of land and the pledging of cultivation rights invalid in law. The attempt to develop mixed farming and a sense of ownership in the land must not be considered as a universal and immediate panacea for native agricultural ills.

If all the principles were carried out universally and to perfection, Africa would have no soil erosion and overstocking problems. No less than any big capital scheme for combating erosion, it would, however, if put into immediate action, cost thousands of pounds; but as nothing can ever be hurried where the farmer is directly affected, it is matter of slow development, with consequent comparatively low annual cost, which is more acceptable to those concerned with raising the money. In the last decade considerable knowledge of practical value to the native in his agriculture has been acquired, but no really suitable method of extending these practices to the native in his own village has been propounded. Governments are generally unwilling to facilitate the execution of such practices

by legislation. and even this method, where attempted, is not always satisfactory. There is no way therefore of driving a large community to adopt new methods on a large scale in a short time. It is common knowledge that the native in his own environment is subject to mass criticism based on arguments derived from custom or indifference, and is often unable, owing to the very nature of his existence, to put proffered advice into practice. It is in overcoming these difficulties that the groups in which native holdings are being established are considered to be serving a very useful purpose. Whilst occupation is at present the simplest means of maintaining a reclaimed area free from tsetse-fly, it must not be overlooked that without adequate supervision the one enemy—"fly"—may be replaced by the equally dangerous ones of soil erosion and overstocking. Supervised settlements are ideal in this respect, but supervision is not always available. The only other expedient is a proper allocation of the land to sufficient families to maintain a balance. Even this can only be a temporary measure, as the plan will inevitably break down somewhere unless a nucleus is established from which improved methods can spread to the perimeter. As an immediate combative influence therefore, strictly supervised settlements would be too costly on a large scale, at least at the present early stage of development; on the other hand, the alternative method is likely to lead in time to devastation which it is wished to avoid. It is important therefore that nuclei should be set up from which a balanced agriculture can develop, and which will in time exert an ever-increasing influence over the population around them. It is with this aim in mind that the native smallholder is being established in settlement centres under supervision.

The aims are briefly:—

(*a*) To evolve a type of holding which will carry sufficient stock to enable the peasant to maintain his land in a constant state of fertility. Even so little as two acres of pasture under rotational grazing, simply practised by tethering, can be made to carry one beast in the Lake Province of Tanganyika.

(*b*) To introduce systematic methods by allotting a conveniently shaped holding which will enable the farmer to keep a ready eye on his crops, and to reduce time lost in going to work. Further, by this means he will be able to spread manure with least effort, and contour his land as a unit, and not as a fragment with other unattended fields above him.

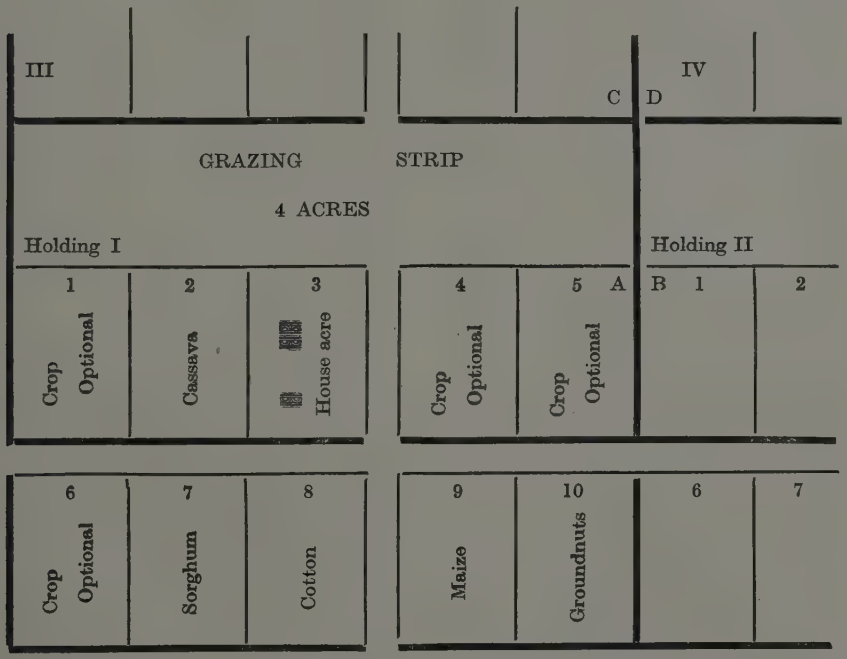
(*c*) To improve the quality of cattle he may keep, so as to afford him a second means of obtaining wealth, without necessarily having to hold them in large numbers. This may be done by improved methods of feeding, which are concomitant with less stock, and by affording facilities to obtain selected beasts of known quality.

(*d*) To embody in his crop programme a system of crop rotation which will amplify the effects of (*a*) and afford a safeguard against the undesirable extension of a single crop.

(*e*) To give the native an interest in, and a right to, his land without allowing him to offer it as a security against loans.

The area to be settled will invariably be sited in unoccupied land where water must be available. Great difficulties will otherwise be encountered in re-arranging fragmented holdings. This difficulty may,

of course, be reduced as the scheme progresses. The acreage to be allocated to the family will vary, but may be taken as an average of 15 acres. The size of the holding depends on the quality of the soil. Especially in occupied areas, reallocation and exchange of land might involve the parcelling out of the poor land—often as much as 50 per cent in the cultivation steppe—into grazing reserves for each individual, which would naturally allow the holdings to carry more cattle. Owing to the nature of the land, it may not always be possible to make the plots of equal shape or even single units. In the Lake Province of Tanganyika the all-important sorghum is invariably grown in the heavy black valley soils to which few crops are suited, and as these valleys do not provide suitable sites for erecting huts the necessity of having two units of land might arise, where otherwise the holding would be too long and narrow to be workable. With only the native hoe, it is not easy to recondition the texture of the soil by drainage or tillage to suit the crop. A plan of a typical holding may be somewhat as in the following plan:—



In uncleared bush, occupiers might prefer to build their huts at A, B, C and D until such time as the land was cleared and free from game. The grazing area should, as far as possible, be sited along the prevailing contour, with a line of sisal or other suitable plants to prevent erosion on the lower side of the strip. Whichever boundaries of the acre plots run along the contour can be planted with khus-khus grass (*Vetiveria zizanoides*), or other suitable hedging plant. It may be found preferable actually to set out the base lines of the farms themselves on the contour, or alternatively to lay out a number of big main contour ridges through the whole area, which the holders can afterwards follow.

In order to give the reader a conception of what rules the peasant holder might be bound to follow in accepting a holding, a set of regulations proposed for a particular settlement, and as yet not officially confirmed, are set out below. These rules have in fact been accepted by each individual holder before taking up his land:—

Proposed Rules for Kingolwira Settlement

1. The applicant must agree to be a bona fide cultivator who will maintain his land clean and in a good state of cultivation and fertility, taking such precautions as are necessary to counteract erosion.

2. He must cultivate and graze only within his demarcated boundaries as far as his activities in the settlement are concerned.

3. He must plant and tend sufficient acreage of food crops to maintain the family registered as occupying the plot. [Every native, in any case, is obliged to do this by the native authorities if he has no other means of support, whether he is in a settlement area or not.]

4. He must agree not to fragment his land by offering part of it to any other person, nor shall more than one heir inherit the land, its buildings and permanent crops.

5. The live stock he may acquire must be accepted by the Agricultural Officer as suitable and must pass through a recognized quarantine before reaching his holding. He must also adopt such methods of animal husbandry as will maintain his arable holding and grazing in good condition, the head of stock not exceeding the number laid down as the maximum for the particular local conditions.

It has been found that smallholders are able to acquire more than the average amount of cash from their crops. Three demonstration holders in the Morogoro District in their first year accumulated Sh. 225 each, in addition to their food crops, from six acres of land, without any outside help whatsoever. A favourable factor in popularizing the scheme is the general lay-out of the settlements, which avoids the haphazard fragmentation of bush and the resultant islands of vermin-infested country in the centre of occupation. Although the isolation of the hut, contrary to native practice, at first appears to them unfavourable, their central position in the plots is soon manifested to them as an advantage, in that it facilitates the defence of the crops. The siting of the cassava acre next to the house is an undoubted advantage, both from the above and the manurial point of view. There are, of course, numerous points which, although very necessary, do not at first favour the popularity of the scheme. Amongst these may be cited the forbidden fragmentation of the *Matongo*, which is so common where the son-in-law has to build on the father-in-law's plot till the payment of the dowry is completed. Again, in certain cases there might not be a sufficiently wide choice of soil, or the lack of riverine land might be deprecated. However, it is indeed surprising how the native will adapt himself to new conditions when he sees them already being practised around him. Take as an example the planting of crops in lines: a case exists where the first half-dozen holders were taught to follow the method, and since then the idea has been adopted by all and sundry with hardly any supervision. This is an important point. So long as he is in an enlightened community, progress follows naturally; whereas in the native reserve he is fighting against public opinion the whole time. No difficulty is found in establishing new varieties of crops in the settlements, and the introductions have invariably led to good results. An important factor in the training of the native mind, particularly in the development of the power to compare, and to escape from the general to the particular, is the measurement of the holdings in acre plots. He is then able to measure his yields year by year with the yield and the climate as the only variables. In ordinary native agriculture, it is

no unusual circumstance to hear a man extolling the excellent yields obtained in a particular year and to find on examination that he planted a larger area on that occasion. The detailed surveying of each holding will not necessarily always be practicable, but in the initial stage it certainly simplifies supervision, and is an education in itself to the native. Where the holders have reached the stage of keeping cattle they have taken quite readily to the practices of pail-feeding the calves, tethering the cattle on grazing, stall-feeding in the evening, and using the oxen for ploughing. The good condition of the stock also helps to establish the argument that mixed farming with a small number of stock, as compared with the previous custom of ranching twice as many scrub cattle, will not necessarily lead to any decrease in total value. It is a fact that the unit of land worked and the value of crops received by the smallholder are considerably larger than the average outside the settlements, the amount of uncontrolled erosion is certainly less, and food shortages are not so prevalent. The peasant holders are more ready to accept and follow advice, and are generally better citizens.

As yet there is no positive knowledge that the manure obtained from the five to eight beasts kept on the holding can permanently maintain, with the additional help of crop rotation, an average of ten acres under cultivation. It is known that small applications of manure of two to four tons per acre produce an economic response in the yields of crops so treated, and that large applications are often not only unnecessary but not beneficial. One beast can produce from two to four tons of farmyard manure per annum, so that on a ten-acre holding two of the eight acres under annual crops can be dressed at the rate of from four to eight tons per acre per annum, whilst the cassava and house acres can be dressed every other year at the rate of two to four tons per acre. No doubt the system, if not entirely satisfactory, can be modified, either by a re-proportioning of arable acreage to the number of cattle, or by laying down to grass some arable land from time to time. There is at the moment, however, no cause to think that this will be necessary.

There is every reason to expect that a balanced agriculture will develop, based on a wise and wide choice of crops in conjunction with the proper use and treatment of cattle. The use of cattle for draught purposes will allow the native to expend more of his time in attending to the improvement of housing and hygiene, the manufacture of dairy products, and the maintenance of soil fertility, in particular anti-erosion work. It is confidently believed that new practices will spread to some extent naturally, as applicants for holdings enter into their new environment, and it is expected that as the yearly advance into new land is made the plan will be to appoint the most experienced and enlightened of the holders as the leader of that community of, say, thirty peasants, who have already adopted the new methods. The existence of such organized settlements will afford admirable opportunity in the future for all departments to graft their own improvements into the native domestic, social and educational life. The introduction of this balanced agriculture into newly developed country would avoid the repetition of the devastation which has already taken place in over-populated areas, providing that immigration was not rapid. One can take it for granted that if huge tracts are to be cleared of "fly" and hasty occupation is necessary to prevent regeneration of bush, then all the effort is wasted, because erosion and eventual overstocking will almost certainly ensue.

Some Mechanical Characters of *Agave* Fibres

By F. J. NUTMAN, *M.Sc., A.R.C.S., D.I.C., Plant Physiologist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

The fibres of various species of *Agave*, mainly of *A. sisalana*, have until recently been used for little but the making of binder twine. For this they are suitable both in strength and in other characters. There has therefore been but little incentive to detailed study of the fibre.

The position has now changed. *Agave* fibres are coming into use for an increasing number of purposes, which range from the making of ropes to the manufacture of fine twines and yarns. These purposes are more exacting in their requirements, and probably each purpose will have a different requirement. Because of this, knowledge of the physical qualities of fibre is desirable; for it should be possible to correlate physical with technical qualities and thus to select new *Agave* types on the mechanical suitability of their fibre for specific purposes.

Had the manufacturers been in a position to state their requirements this work would have been much simplified. This information may eventually be forthcoming as a result of the technical researches now being carried out at Lambeg. When work was started at Amani, however, no research in Europe had been suggested, and our attention was therefore confined to those characters that appeared readily measurable and at the same time held out promise of being eventually related to technical performance.

In any event, accurate sampling and measuring technique had to be worked out somewhere, and East Africa is very suitable for this purpose. Ample material is available. Native labour is peculiarly adapted to testing work; the African does not get bored, and, for a small wage, can repeat a simple sequence of actions indefinitely with no falling-off in efficiency. No normal European could support the monotony of an apparently endless sequence of breaking-strain determinations.

METHODS

All our determinations of breaking strains of sisal have been made on a machine designed and built at Amani. It has been exhibited, working, at this year's agricultural show at Nairobi.

Fig. 1 illustrates diagrammatically its principle. If a weight of one kilo be held in the hand with the arm hanging vertically, it is hardly felt; but when it is slowly raised, until the arm is horizontal, the strain of supporting it can be felt to increase. The human arm is replaced by the weighted lever of the machine, pivoted on ball-bearings and carrying a cam at the top. A flexible connexion between this cam and a suitably geared motor pulls the lever upwards, so that a steadily increasing load is applied. Part of the connexion is formed by the fibre under test. When the fibre breaks, the lever is held in position against a calibrated arc by a trailing pawl, and its position indicates the actual breaking-strain of the test-fibre.

This machine, operated by an African, can break between 250 and 300 fibres per working day. It has given trouble-free service for several years, and has broken a total of nearly half a million fibres.

Commercial sisal fibre is a mixture of fibres which vary greatly in length, in size and in type. Each fibre also varies in its qualities at different points along its own length. The first problem, therefore, is to choose the most suitable portion of the fibre for the measurement of its qualities;

the second, to select a suitable number of fibres from a bulk sample in such a manner that they shall be truly representative of the bulk, and thus that their average shall differ from that of the bulk by not more than a known amount.

strength, or at some distance along the fibre that is a definite proportion of its particular length. This is not possible, for practical reasons, and it is necessary to select some point on the *hank* of fibre for testing. Taking the average length of sisal

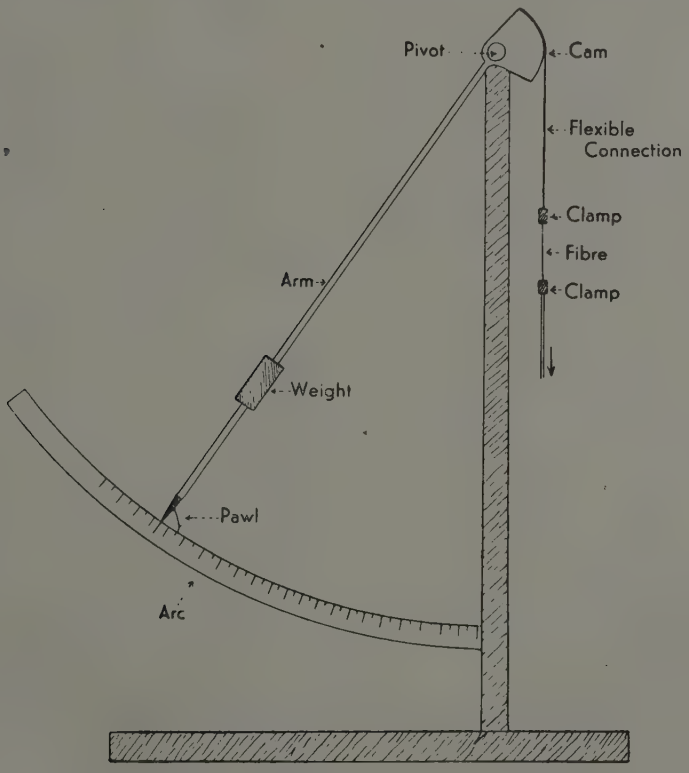


FIG. 1.—Diagram of the Fibre Testing Machine designed and made at Amani

The strongest point on any fibre is at approximately one-third of its length from the butt end. The strength falls off uniformly on each side of this maximum point, and at the butt end is only 67 per cent of the maximum. Two-thirds of the way along the fibre from the butt the strength is again only 67 per cent of the maximum.

It would, of course, be desirable to test each fibre at its point of maximum

fibres into consideration, the portion of the hank at about 25 cm. (10 in.) from the butt end has been chosen as the standard for all routine tests. The effect is that the majority of the fibres are tested near their point of maximum strength, and moreover most of the short fibres are included, although, on the other hand, these are tested towards their tips and the longer fibres are tested towards their base. If the results of testing are to be repre-

sentative and reproducible, it is necessary to select the sample for test in a random manner from the bulk of fibre. This is more difficult than would appear, and many thousands of tests were made before a reasonably satisfactory method was found, which is as follows:

From the main bulk of fibres several dozen small hanks are taken at random until a bunch of about 6,000 fibres is obtained. From this, at 25 cm. from the butt end, a 5 cm. length is cut. The remainder is discarded. These 6,000 fibres are from a number of leaves, and in order that our final sample for testing (which has to be between 600 and 1,000 fibres) shall be truly representative, each leaf has to contribute fibres to it in a random manner.

In other words, the sample has to be shuffled completely before the final test sample is taken from it. This is extremely difficult to do, since the fibres from each leaf tend to stick together and to pass as a unit through shuffling processes. This is well seen by staining half of a fibre sample, and then shuffling by hand in the dark. Very little mixing is ever achieved.

If all the fibres are put into a jar, which is then rotated for four hours on its side at a speed just below that at which the fibres are pressed against the sides by centrifugal force, mixing takes place. This machine has been demonstrated at the Nairobi show. From the mixed sample, six separate sub-samples of a known number of fibres, at least 100, are taken and weighed. All the fibres are then broken individually on the testing machine.

Results

At the conclusion of each test the following information is available:—

A. The "Fineness" of the Fibre ("*F*").—This is obtained by calculating the average weight of the single fibres (all of equal length) composing the sample. The smaller the weight, the finer the fibre.

B. The Tensile Strength of the Fibre ("*s*").—This is the average of the breaking-strains of the fibres composing the sample, recorded in grams.

C. The "Breaking-length" ("*L*").—This is a somewhat imperfect measure of the actual intrinsic strength of the fibre-substance, and is more or less independent of the fineness. The higher this value, the stronger the fibre is, intrinsically.

Table I presents some results for East African unbrushed fibre. These figures are chiefly useful as the background against which future fibre data can be reviewed. They show also the range of variability to be expected from any new clonal variety under normal commercial conditions. They are, however, worthy of a moment's consideration on their own merits.

The average breaking strain of commercial sisal can vary from 1,100 to 2,000 grams; the fineness from 2.8 to 4.7; the breaking-length from 34 to 56. There is no marked correlation between fineness and breaking-length or between breaking-strain and breaking-length. In addition, no general relationship is apparent between the "cut" and the mechanical characters of the fibre.

Sisal, we know, is a clone. We should expect therefore the mechanical properties of fibres from plants grown under identical conditions to be closely similar. It is indeed probable that the greater part of the variation seen in Table I is due to differences in the environment in which the plants are grown. For instance, although two estates, D and E, which show very similar fibre characters, are within a few miles of another pair, H and F, the fibres of the two pairs differ markedly.

All four estates are close together, but D E and H F are on fundamentally different soil types. This is probably the correct explanation of the differences in the fibres they produce.

Such conclusions, of course, are tentative. The main use of the results is to exhibit the *range* of fibre variation and for comparison with results from new *Agave* types.

The data for blue sisal show that the fibre is considerably finer than sisal, and at least as strong; even though the greater length of the fibre normally given by this species would tend to increase the coarseness. If fibres of equal length were compared, the difference in fineness would be accentuated.

The Application of Mechanical Data

In addition to their main use in facilitating selection of new *Agave* types, data obtained by the methods described above can contribute to the solution of a number of practical problems. As an example, I will discuss the vexed question of the maturity of sisal leaves.

That the sisal leaf "matures" on the plant is a generally accepted belief; it would appear to be reasonable, and can be re-stated thus: "The leaf of sisal, when it unfolds from the central bud, does not contain its full complement of fibres. These are weaker, lighter, and generally inferior to those which it will contain later in its life. As the leaf gets older, and assumes a low angle on the plant, it matures, and when it is at an angle of 45° or 50° to the horizontal it is 'mature' and fit for cutting."

Since we cannot in practice examine the fibres of any one leaf at successive stages of its growth, we may adopt the expedient of regarding the older leaves on the parent plant as affording a fair sample of what the young leaves will become. At the same time, the possibility must be considered that a plant may at successive stages of its growth lay down fibre of different qualities in the leaves that are produced at each stage. Taking full account of this possibility, the studies made here and independently confirmed by Mr. G. W. Lock, the officer in charge of the Sisal Experimental Station, Ngomeni, lead to the conclusions that:—

(1) The average strength of the fibre in a leaf increases with the age of the plant at which the leaf was formed. This increase is due to an increase in the proportion of the strong fibres. The intrinsic strength (i.e. "breaking-length") also increases slightly.

(2) The number of fibres per leaf and the weight of fibres per leaf remain relatively constant, at least over the period when cutting normally takes place.

(3) There are more long fibres in the later leaves.

(4) It is probable that the proportion of long and short fibres, the number, the weight, and the strength of the fibres from a leaf does not alter to a sufficient extent to be commercially detectable after it has unfolded from the central bud.

Thus we are of the opinion that "maturation of the leaf" does not take place; or rather that it takes place too early in the life of a leaf to be of any commercial importance. No adverse effect on fibre quality or quantity should be detectable, even were the leaves cut right up to the central bud.

This does not, of course, mean that such action is advisable. The leaves of sisal photosynthesize organic material, which enables new leaves and fibres to be produced. They also contain reserves of

water and organic material. The removal of the leaves by cutting thus reduces both the power of manufacturing fresh material and also its reserves. If cutting is too severe, the production of new leaf material must suffer.

I am unable, at present, to give any opinion on the optimum severity of cutting. Experiments now in progress at the Sisal Experimental Station, Ngomeni, should settle this. But we now know that the only criterion to apply to these erperiments is that of the after-effect on the plant. Any degree of severity is permissible without affecting fibre quality.

TABLE I

STRENGTH CHARACTERISTICS OF EAST AFRICAN FIBRES

(Each figure is the average of sextuplicate determinations comprising a total of about 1,000 fibres.)

First "cuts"—(Sisal)

Estate	"F"	"s"	"L"
A ..	3·11	1592	51·6
B ..	4·49	1678	38·2
C ..	2·93	1614	56·4
D ..	2·99	1245	41·6
E ..	2·86	1210	41·6
F ..	3·76	1842	49·6
G ..	3·41	1140	33·6
H ..	3·13	1741	54·9
I ..	4·47	1956	43·6

Second "cuts"—(Sisal)

Estate	"F"	"s"	"L"
B ..	3·49	1669	48·4
C ..	3·92	1562	39·9
D ..	3·16	1184	37·4
E ..	3·24	1332	41·2
I ..	4·39	1813	41·8

Third "cuts"—(Sisal)

Estate	"F"	"s"	"L"
A ..	4·67	1785	38·4
B ..	3·38	1905	48·9
D ..	2·97	1189	40·1
E ..	3·29	1400	42·5
G ..	2·97	1094	39·6
I ..	3·29	1869	43·6
J ..	4·68	1706	36·9

First "cut"—(Blue Sisal) :—
"F" 2·62 ; "s" 1001 ; "L" 39·6.

Second "cut"—(Blue Sisal) :—
"F" 2·20 ; "s" 984 ; "L" 45·3.

N.B.—

(1) A and B are Tanganyika coastal estates.
C is a Kenya coastal estate.
D, E, F, G and H are estates in the Tanga Province at varying distances from the sea.
I and J are Kenya inland estates.

(2) The figures for "F" are moderately accurate.
The values of "s" are subject to an error of 100.
The values for "L" are subject to an error of about 1.

A Long Term Programme for Maize Farms

By MAJOR H. P. HILL, *Hoey's Bridge, Kenya Colony.*

The writer submits that the time has now come when the farmer should—

(1) Make up his mind that the fertility of his soil can be greatly increased;

(2) Decide on a programme to bring about such increase in fertility.

Some farmers appear to take poor maize yields too much for granted, and it is with the hope of stirring them out of this rather pessimistic attitude that these notes are written.

To increase the fertility of the whole of a farm's arable land, a long term programme has to be undertaken, and it is hoped that these notes will help farmers to frame one and carry it out.

It may be argued that, owing to fluctuating prices, it is very difficult to lay down a hard and fast programme to be carried out over a number of years. There is nothing in the scheme here outlined to prevent a change of crop, so long as the general manuring practice is carried out at the same time; and probably the farmer is wise to stick to the crop he knows his farm grows best, despite fluctuations in market prices.

The great drawback to Kenya is the lack of rotational crops which have a market value. No doubt, as dairying increases, crops suitable for stock feeding will make up this deficiency. When this happens, such fodder crops can partly take the place of maize, but should not interfere with the main manuring programme.

It is generally admitted that the limiting factor to soil fertility is humus, which is so easily lost by erosion in Kenya. If so, then fertility can only be restored and maintained by adding humus and keeping it on the land.

From trials lasting over a period of fifteen years there is no doubt whatever in the writer's mind that nothing compares with organic manure in raising fertility, and this programme will be found to rotate round dung.

With regard to anti-erosion work, all farmers must really grasp the nettle and start terracing at once. When once started, the work is not nearly so terrifying and difficult as it sounds, and every year it is postponed our rainfall will have further decreased our soil fertility and more expense will be incurred in replacing it.

It will take some years to terrace the whole of the arable land. In the meanwhile, erosion on the non-terraced land can be diminished by leaving strips of uncultivated land across the slopes, such strips forming part of the fallow (see below). These strips, however, can only act as a palliative and not as a cure for erosion. Terracing must be carried out steadily until completed.

In regard to any given farm operation, it is not only the cost that has to be considered but also how the operation can be worked into the farm routine so as to interfere with the main work of ploughing, sowing, weeding, and harvesting as little as possible. One wants to avoid the very harassing feeling of being late with the farm work, and after years of rather careful thought and trial the writer is quite convinced that land due for a manuring should be left fallow. By so doing, the farmer is able to get the manure hauled, spread and ploughed under before the busy ploughing and harvesting season starts. If the farmer tries to manure during the busy season, he will get late with his work, and

manuring will take second place and be skimped.

To start with, the farmer has to decide how often his land should be manured. Land should receive 10 to 20 tons of manure every five years at least, i.e. four years' cropping and one year's manuring. If manuring can take place on any given piece of land every fourth year, so much the better, but that would mean one-quarter instead of one-fifth of the land out of production. The benefits of manure can easily be seen in the fourth crop after manuring. "Little and often" is the slogan for manuring, but this is, in practice, impossible to carry out if the acreage is reasonably large.

We will suppose that the farmer decides on dunging any given piece of land every five years. He will therefore leave approximately one-fifth of his arable land uncropped in rotation every year, either in one block or in strips for anti-erosion purposes.

It is a debatable point what should be done to the fallow land prior to manuring. The writer is of opinion that Africa loves to be left entirely alone now and again, and therefore suggests that a weed fallow be left. Weeds soon cover the ground, form shade for the soil, and help to hold up the force of the rain. On the other hand, some green crop can be grown, to be ploughed under with the dressing of manure later. Both weed trash and green manure crops help to bulk up the manure when turned in with them. It is hardly necessary to warn the reader against a bare fallow.

Most of the land in Kenya suffers from weak patches. The year before any land is due for fallowing, such patches, if not too numerous, should be clearly staked off with stout long pegs, easily seen, when the maize is high enough, to demonstrate the weak patches. When harvest is finished, these patches should be *thickly* covered with maize stalks which should be left there right through the fallow period the next year. It is almost unbelievable what such a thick covering will do to benefit the land. These bad patches will of course receive their quota of manure when the time comes, and will therefore benefit twice over, from the mulch and from the manure, which should bring them up level with the better land that has received manure only. Stalks would be scattered over a wider area before ploughing, so as not to choke the ploughs.

After the main crop has received the necessary attention, every available farm hand should be employed in cutting bedding for the oxen, for present and future use.

After many trials, the writer has found that to make enough manure for any reasonably large piece of land (such as one-fifth of the total arable), it is necessary to start preparing the manure the year before it is wanted. Also, it is obvious that the haul to the *shamba* should be as short as possible. Movable *bomas* made of rough posts, wattle cross-bars or pig-netting, should be placed near the land to be manured. When enough manure has been made for any given portion of this land, the *boma* can be lifted in a day and moved to serve another part of the land.

Every conceivable kind of roughage should be cut and collected at the *boma* sites. The larger the variety of bedding the better, as it then rots more quickly. An adult native can easily cut close to ground level 400 square yards a day with a sickle, and a hay mower will greatly assist, where there is an area clear enough for it to work without damage. Maize stalks are awkward and bulky to move, but a sled made of wattle poles attached

at right angles to a long drawbar, makes for a low pitch for stalks or any roughage, and can immediately be unloaded at the *boma* by the team dragging the load clear of the sled. Maize leaves and sheaths should not be left behind, as they rot down very quickly in the *boma*. It has been found that four boys, a *toto,* and six oxen should be kept continuously at work right through the year bringing in bedding to *bomas* and sites of future *bomas*. This outfit should haul off to *boma* sites as much maize trash on the *shambas* as can be managed without holding up the ploughing, even from *shambas* which are not due for manuring for two, three or four years. Stalks are slow to rot, but if collected through the years they will be half way to good manure before ever being used for bedding. Shifting of stalks will appear cumbersome and slow, but it should be remembered that no labour is required to cut them, as in the case of grass, because where stooking is practised the cutting has been done in the course of that operation.

It is the experience of the writer that the preparation of manure for any piece of land should start in one April and cease in the next. This allows the latest made to rot down sufficiently for application to the land the following August. The first made manure could be carted and heaped on the *shamba* earlier than August and lupins sown on the heaps to add nitrogen and bulk. The actual moving of the manure to heaps acts as a turning, which is advocated by the Indore method of compost-making.

To make all this clearer, the farm is divided into five parts—A, B, C, D and E. A is due for a fallow and manuring in 1939. Make manure for A from April, 1938, to April, 1939. Then move *bomas* to patch B (to be manured 1940), and make manure for this land until April, 1940, and so on from year to year.

Manure should be spread and ploughed under as soon as the land becomes dry enough in August or September. Great efforts should be made to get this ploughing done before the main ploughing starts so that, when the farmer starts with the busy season, all the year's manuring is behind him. Care must be taken that manure carts do not puddle the land, but if haulage starts early, say May or June, the farmer will have ample time to pick his weather for haulage.

By the time the planting season of the next year comes round the seed bed in the manured land will have become stale, and should be stirred up with a tined cultivator before seed is sown. The writer finds that the quickest way to do this is to put in all the maize cultivators and let them go across the land like a pack of dogs, leaving no land uncultivated.

One will be met with the objections to the amount of labour all this will require, but it will be money well spent. Labour, it is contended, will be far better employed thus than in worrying about with odd crops that probably will not pay commercially. The most expensive manuring the writer has ever done cost Sh. 13 an acre. The farmer can look for at least fifteen bags an acre increase, spread out through the years until the next manuring is due; so there will be a good profit on manuring costs and the land will be kept in good heart.

An objection may also be raised to keeping one-fifth of the land out of crop. It is submitted that, when once the system is in full swing, the farmer will be getting more bags of maize off the four-fifths of his land than he did from the whole of it.

It should be remembered that these notes are written for the maize farmer, and they may appear to run counter to mixed farming. The writer must plead guilty to being entirely in favour of one-

crop farming, if the alternative is spending time and money on other crops, few of which ever pay. The growing of fodder for stock is entirely different, and to be encouraged, of course, but the above system should still hold good, except that some fodder crops could be sown in the land to be manured instead of leaving a weed or green manure fallow. But such fodder crops should be sown early enough to be cleared off the land in time for manuring as outlined above.

Not being one himself, the writer is shy of suggesting that this scheme could be applied by coffee planters who have also maize lands, but he thinks this scheme could be carried out by them. Probably the planter has less land under maize and so less to manure.

Wheat farms could certainly be treated, the wheat farmer having more time to devote to the work.

In the case of large maize farms, one-fifth would probably present too great an undertaking. If so, half of one-fifth could be manured and the other half green manured, care being taken that, when that one-fifth is again due for treatment, the operations on its two halves are transposed.

The writer has tried laying land out for two years under a weed fallow, but it has been found that the land becomes choked with grass and couch, and that too much money is required to clean it up for the coming crop.

The writer has exploded, to his own satisfaction, the myth that manuring is not worth while, owing to the very limited area which can be treated in any one year. If the land is laid fallow, and the manuring organization framed so as not to interfere with the work on the main crop, substantial areas can be manured.

To revert to the matter of hauling bedding to the *boma* sites, if roughage is far from the land to be manured, it is wise to site the *bomas* near the roughage supply and cart the manure over the distance, rather than the roughage, as the manure is more concentrated. With regard to land so situated, greater care should be taken to make use of all maize stalks on it, *boma* sites being chosen near in to deal with these, as well as others further out to deal with the roughage.

The writer has made no mention of compost-making, as he is of the opinion that it is too expensive. He would rather use the labour for cutting more bedding. The heaping of manure in *shambas* before spreading will act as a turning, as pointed out above. The writer believes that heaping manure in *shambas* is not generally favoured by experts, but African labour is not up to spreading evenly from a cart. Manure spreaders would probably do the work well, but they are expensive.

Plenty of bedding should be spread daily in the *bomas*, especially in the rains, to prevent the *bomas* becoming too messy for the cattle to lie down comfortably.

It is generally accepted that Kenya requires more settlers. The best publicity for the country is paying farms, and it is submitted that a well-organized manuring programme will surely result in maize farming that pays.

Some Observations on the Hygroscopic Properties of Dried Coffee Beans and Berries

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INTRODUCTION

During the progress of Robusta coffee breeding work at Kampala, it has been the custom to estimate the size of the beans of individual trees on samples of one hundred berries. These were weighed, pulped, fermented; and the resulting coffee in parchment was dried, weighed, hulled and weighed again, in order to ascertain the weight of the beans.

Even with such small quantities of beans it was found that there were considerable variations between the weights of any one sample from day to day; and that, during the course of a single day, a sample might lose an appreciable amount of weight which, however, would often be regained during the next night. As all this work was performed in a well-built, dry laboratory in a district where the air is seldom saturated with moisture—the average relative humidity for 1935 at Kololo, Kampala, was 82 per cent at 8.30 a.m. and 65 per cent at 2.30 p.m.—it was obvious that coffee must possess marked hygroscopic properties. It was thought that the matter was worthy of investigation, for it was of interest, not only in this estimation of the bean size of individual trees, but also it had some bearing on the problems of coffee preparation and storage. Of course, it has long been known that if in the process of curing coffee a batch is dried too much it will pick up moisture again when it is exposed to the air.

METHOD OF INVESTIGATION

Both Robusta and Arabica coffees were studied. The methods employed were the same but, unfortunately, it was not possible to start the experiments at the same time, for the two types seldom bear a heavy crop in the same months. In this experiment the Robusta coffee was picked and treated on the 21st February, 1936; the Arabica coffee on the 26th March, 1936.

A bulk of coffee, freshly picked, was brought into the laboratory, and from this there was sorted out by hand two lots, each weighing one kilogram, of cherry. No unripe, over-ripe, or damaged fruits were included. One batch was spread out in a shallow wooden box to dry, being placed in the sun each morning and returned to the laboratory every evening; while the other was pulped, fermented under water for 42 hours (in order to ensure that all sugar should be removed), washed and dried for one day.

From this fermented coffee there were then counted out four samples, each of two hundred beans, which were treated in the following ways:—

1. Dried in the sun outside from 8.30 a.m. to 3.30 p.m., and brought into the laboratory each night.
2. Dried on a bench in the laboratory—a well-ventilated room.
3. Dried in a desiccator.
4. Dried in a water oven.

These samples, and also the bulk of drying coffee in cherry, were weighed at 8.30 a.m. and 3.30 p.m. each day.

When the coffee, dried in cherry, had reached a constant, or rather, a fluctuating weight, samples of one hundred cherries were taken from it, and these were treated thus:—

1. Hulled and dried in the water oven.
2. Dried in the water oven without hulling.

3. Hulled and kept in a damp chamber, i.e. in a desiccator the bottom of which had been filled with water instead of a drying agent.
4. Kept in a damp chamber without hulling.
5. Hulled and dried in the sun.

The moisture content of the samples was estimated from the loss on weight on those which were dried in the water oven; in spite of the fact that glycerine had been added to the water in order that the temperature might be maintained at 100° C.—at Kampala water boils at about 95° C.—two or three days were required before the samples reached constant weight.

Results

1—*The Process of Drying*

In both species, the coffee in parchment could be sun-dried more quickly than that in the cherry; the former reached the minimum water content in nine days, but the latter was not dry until after thirteen days, although it was spread out in a single layer. In ordinary practice, when a large bulk is handled, the coffee cannot be spread so thinly, and therefore it would take much longer to dry. When the daily values of the moisture content during the process of drying were plotted, they formed a somewhat irregular curve, for it was obvious that the process was influenced by the weather.

Samples of parchment coffee were dried under more uniform conditions, in a desiccator, and their moisture contents, when plotted, formed smooth curves. The loss of water was rapid at first, but became progressively slower; even after forty days in the desiccator the moisture content did not fall below 5.3 per cent, and it appeared that the residual water was firmly held in the bean.

The table below shows the moisture content of Arabica and Robusta coffees when fresh and when sun-dried to the minimum weight recorded during the experiment. As shown below, this condition was not stable, for coffee when dried to this limit rapidly picked up water if conditions became somewhat moister.

	Arabica	*Robusta*
	%	%
Ratio of *buni* (sun-dried cherry) fresh cherry	36	39
Moisture content of fresh cherry	69	66
Moisture content of sun-dried cherry	13·9	10·9
Moisture content of bean only	9·4	9·5
Moisture content of pericarp only	18·6	12·7
Ratio of dry bean/sun-dried cherry	52	54
Ratio of dry bean/fresh cherry	19	21

It may be noted that in the course of investigations on the bean size of the various coffee progenies, it has been found that there is a considerable variation in the values of the ration dry bean—fresh cherry for different trees. Usually, the larger the bean the higher this ratio is. Values for Robusta coffee are most often between 16 and 28 per cent, and the average for most progeny rows is about 22 per cent.

It was found that while the moisture content of Arabica *buni* (sun-dried cherry) was much higher than that of the Robusta *buni,* yet the percentage of water in the bean of both samples was almost identical (9.5 per cent and 9.4 per cent). It followed therefore that the percentage of water in the dried pericarp of Arabica coffee was much higher than in that of Robusta coffee (18.6 per cent as opposed to 12.7 per cent). Such a result is only to be expected, for it is common experience that the juicy berries of Arabica coffee are more difficult to dry than are the harder berries of Robusta.

The fermented Arabica, under the conditions of the experiment, had a slightly higher water content—about 11 per cent—than the fermented Robusta. Absolute figures could not be given, for

the percentage of water varied from day to day.

2—*The Fluctuation in Moisture Content*

On Diagram 1 the daily fluctuation in the water content of samples of *buni* and of fermented Arabica coffee is shown. It comprises the results of weighings of the bulk of coffee drying in cherry and of a sample of fermented beans. Both lots were weighed at 8.30 a.m. and exposed to the sun each day, weighed again at 3.30 p.m., and kept on the laboratory bench overnight.

The diagram shows that the drying of the coffee was not continuous, and that usually a proportion of the water that was lost when the coffee was exposed to the heat of the sun was reabsorbed during the night. Almost without exception, the lines representing moisture contents of the coffee in the afternoon are considerably below the lines representing moisture contents of the same samples in the mornings. Frequently as much as 2 per cent of water had been taken up in the course of the night, although the samples were kept on the bench of a dry building, the windows

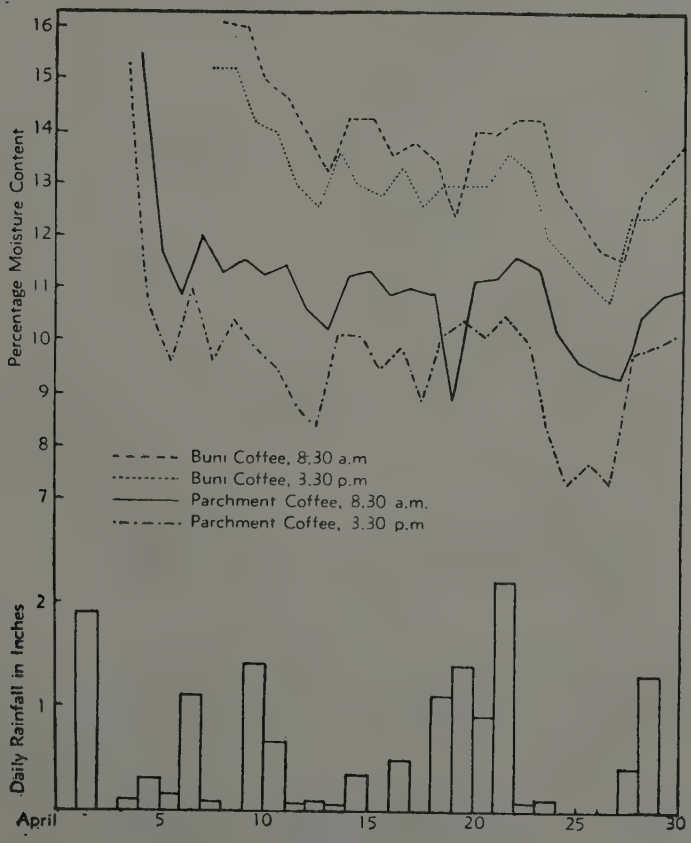


DIAGRAM 1

Arabica Coffee dried in sun by day

of which were closed against the damp night air. In ordinary plantation practice of sun drying coffee, where the coffee is kept at night under a roof of corrugated iron and there is a free ingress of air at the sides, it is probable that much more moisture would be absorbed, especially to 11 per cent). But in both cases the moisture content varied according to the weather, and there was a definite correlation between the rainfall and the moisture of the coffee.

Even when coffee was kept on the bench of the laboratory all the time, and

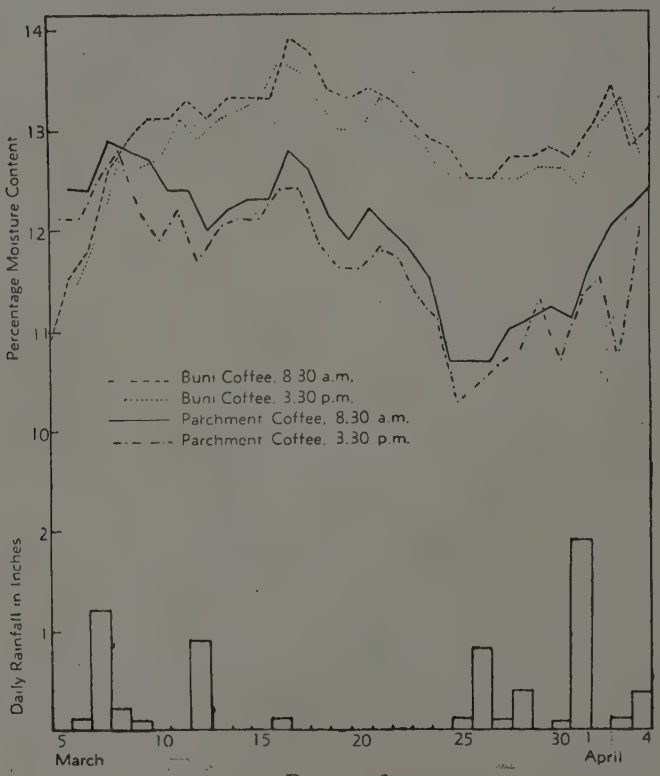


DIAGRAM 2

Robusta Coffee kept in laboratory

in those factories which, for convenience of water supply, are situated at the bottoms of valleys.

Diagram 1 also demonstrates the fact that the water content of dried cherry fluctuated about a mean (approximately 13 to 14 per cent), which was considerably higher than the mean water content of fermented beans in parchment (about 10 not exposed to direct sunlight, the moisture content varied according to the weather. This variation is shown in Diagram 2, on which are plotted the water contents of samples of Robusta coffee, both dried in the cherry and dried fermented beans in parchment.

In this diagram the graphs begin rather differently, because the fermented beans

had been dried on the bench, and the moisture content was still falling at the beginning of the period illustrated, while the *mbuni* coffee (dried cherry) had been dried in the sun and therefore it proceeded to absorb water when it was exposed to less desiccating conditions in the laboratory. After a few days, however, both samples reached a condition of equilibrium, and then their water content fluctuated in unison and in accord with the weather. In both cases it fell during the dry period between the 20th and 25th of March and rose again with the rainy spell at the end of that month and at the beginning of April.

The daily variation in the moisture of this coffee may again be noted. Almost always it was drier in the afternoons than in the mornings, although the differences were much less marked than in the coffee exposed to the sun.

3—*Absorption of Water Vapour by Coffee*

A study was also made of the process of absorption of water by samples of coffee kept under moist conditions—in a desiccator in which the bottom chamber was filled with water instead of a dehydrating agent. The samples employed, all of which had reached a stage of equilibrium with the atmospheric moisture, comprised the following:—

1. Arabica coffee dried in cherry.
2. Robusta coffee dried in cherry.
3. Arabica coffee—fermented beans in parchment.
4. Robusta coffee—fermented beans in parchment.
5. Robusta coffee beans—sun-dried in cherry and then hulled.

The results of this experiment, shown in Diagram 3, yielded interesting confirmation of some phenomena noticed in the drying of coffee. For example, it had been found more difficult to dry coffee in cherry than in parchment (after hulling, fermenting and washing). It was also found that when coffee, dried in cherry, was placed in a moist atmosphere, it absorbed water more rapidly than did coffee in parchment. This property was especially noticeable in the case of Arabica coffee; not only did the dried cherry contain more water when it was in a state of equilibrium with the atmosphere than did Robusta coffee similarly treated, but also under moist conditions it took up water more quickly.

As the samples of the dried cherry became moist they were attacked by moulds which were identified by the Plant Pathologist, Mr. C. G. Hansford, as a mixture of *Aspergillus repens, A. candidus, A. ruber* and *Penicillium* sp. The action of these moulds from the outset must have caused a loss of weight in the samples, and it is therefore probable that the absorption of water was more rapid than is shown in the diagram; and, by the dates marked with crosses, the wastage due to mould action was so great as to cause a loss in weight of the sample.

Both sun-dried beans and beans in parchment of Robusta coffee were tested, for it was thought that there might be a difference between the hygroscopic properties of the samples. The process of fermentation might have affected the bean in some way. There was, however, little disparity between the rates of absorption of water by the two batches. The sun-dried sample contained about 1 per cent more water than the fermented sample at the beginning, and this excess was maintained throughout the experiment. This similarity between the behaviour of the two samples is in agreement with the findings of Case [1] that the normal fermentation of coffee has little or no effect on the bean.

It has been found by Hargreaves [2] that the Coffee Berry Borer (*Stephanoderes hampei*) cannot feed on properly dried coffee, and soon dies. He states that the critical points are 13.5 per cent for

Arabica coffee beans and 12.5 per cent for Robusta. Diagrams 1 and 2 show that under normal conditions the water content of coffee beans in Uganda tends to fluctuate at levels well below these figures; but Diagram 3 shows that, under very moist conditions, coffee might absorb sufficient water to raise its moisture content above the critical point for *Stephanoderes* attack. It is therefore of great importance that coffee should be stored in dry conditions, as required by the legislation relating to coffee grading in Uganda.

2. Under normal conditions at Kampala, the water content of the beans of both Arabica and Robusta coffee tended to fluctuate about a mean of 11 per cent. The water content of the dried pericarp of sun-dried coffee, however, usually was much higher, especially in Arabica coffee.

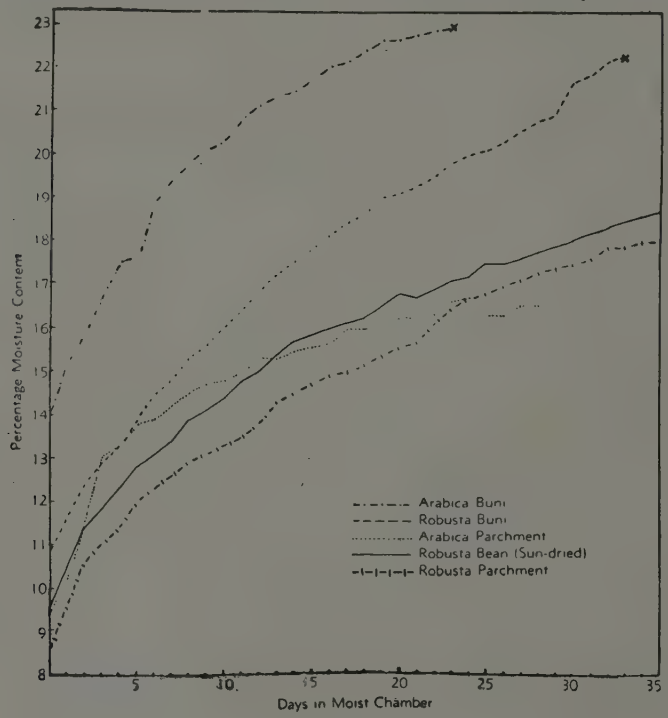


DIAGRAM 3
Coffee kept in damp chamber

3. In very moist air, both the dried beans and the pericarp absorbed water, the pericarp especially rapidly; it is therefore very important that coffee should be stored under conditions as dry as possible.

SUMMARY

1. Dried coffee beans and cherries had marked hygroscopic properties, and their moisture content fluctuated with the dampness of the atmosphere.

REFERENCES

[1] Case, E. M.: Coffee Board of Kenya *Monthly Bulletin*, May, 1936, p. 63.

[2] Hargreaves, H., 1935: *East African Agricultural Journal*, Vol. I, No. 3, p. 220.

The Interrelation of Railways and Agriculture in East Africa

By R. E. ROBINS, *O.B.E., General Manager, Tanganyika Railways.*

A modern writer on the economics of transport has said: "The object of transport is to increase wealth and welfare. This it secures in many direct and indirect ways, of which the chief is that of moving goods and services from points where, being in comparatively little demand, they have low value, to other points where, through being in greater demand, they acquire higher value; it being the test of good management to absorb as little as possible of the increased wealth in the process of achieving it. Thus transport promotes that specialization of function upon which material civilization depends, by making possible an interchange of the products of diverse activities, each separately carried on in the place and circumstances most advantageous to it."[1]

As most real wealth comes from the application of labour to products of nature won from the soil, it will be seen how closely connected are transport and agriculture.

The object of this article is to deal more particularly with the relationship of railways in East Africa with agriculture; but East African railways is a misnomer, for the function of all railways in East Africa goes far beyond the provision of railway-borne services only; all these railways operate inland waterway services, manage the important ports, and some of them operate road services, so that their relationship covers a wider field than is generally recognized.

The past history of the construction of railways in Eastern Africa tends to show that the development of commercial services and the connexion between agricultural production and railways were not in the minds of those responsible for the building of these railways.

It is well known that the building of the original Uganda Railway was to assist in the suppression of slavery and for strategical purposes, and that there was no idea at the time that Uganda would develop into an important cotton producing country; and it is not going too far to say that the fertility of the highlands of Kenya came as a surprise, after the railway had been built.

The Tanga section of the Tanganyika Railways, although commenced by a private company, was taken over by the German Colonial Government, and the extension beyond Muhesa to Mount Kilimanjaro was undoubtedly undertaken for strategical and political reasons, and the economic development of agricultural products which followed the opening up of the country was a result, not a cause, of the railways being built.

Probably the only railway which was built for the development of the resources of East Africa was what is now known as the Central Railway, which was first designed as a short link between the highlands around Morogoro and the Coast. The extension beyond Morogoro, although it was followed by agricultural production—mainly at that time the production of ceara rubber—was directed, not to facilities for evacuating produce of what is now Tanganyika, but to provide an outlet for the very populous areas of Ruanda and Urundi. Those facilities were

[1] *Railways and Roads in Pioneer Development Overseas,* by Holmstoin, p. 21.

not, however, available in the German occupation, and after the Treaty of Versailles the countries of Ruanda and Urundi were administered under a mandate held by Belgium, the contemplated connexion by railway between the Central Line and those territories was never completed, and the railways of East Africa have had very little connexion with agricultural development in that area.

It will be seen therefore that the close relationship which exists between agricultural production and the transport systems of East Africa has taken place in comparatively recent times, and after the original railways had been built. Since that time, however, it can safely be said that the extensions of the railways have been entirely to provide facilities for agricultural produce.

In Kenya, the extension towards Mount Kenya was to tap the coffee-growing areas around Nairobi and the native producing areas between that area and the fertile foothills of Mount Kenya, and the extension to Nanyuki to provide transport for the varied agricultural products of that fertile district. The extension from the main line to Eldoret and Kitale was solely due to the agricultural productivity of the Uasin Gishu Plateau.

It was to assist the evacuation of the cotton crop of Uganda and to avoid congestion on the existing Lake Victoria route that the railway was extended to Uganda, and it was the correlation between railways and agriculture that caused the branch lines to Thomson's Falls and Yala to be built, as at that time Kakamega as a gold-mining centre was unknown.

In Tanganyika, the arguments for the building of the extension to Mwanza and the branch line to Singida were all based upon agricultural production.

So that although the development of agriculture was not considered by the promoters of the original railways, their successors have by no means neglected agriculture in the subsequent policy of providing means of communication.

It would be idle to say that in all cases the results have justified the policy, but it is significant that in no case has it been found economically sound to abandon any of the routes, and it would be only just to say that the volume of agricultural production in East Africa would not have reached the present figure had not the policy of a close relationship between railways and agriculture been pursued.

In one railway the close relationship between agriculture and the railway has the unique distinction of being part of the legal control under which the railway is worked, for the opening paragraph of section 13—surely not an unlucky omen in this case!—of the Kenya and Uganda Railways Ordinance of 1927 reads:—

> "The Services shall be administered on business principles, due regard being had to agricultural and industrial development in Kenya and Uganda by means of cheap transport."

This shows how important the connexion between transport and agriculture was regarded by those responsible for the legislation for the administration of the public transport services, and although the connexion between agriculture and transport in Tanganyika has no legal direction, an examination of the operations of both Departments of the State responsible for these two important spheres of activity leaves no room for doubt that the closest co-operation does and must exist.

What has been the practical result of this relationship? Attention has already been directed to the expenditure of capital on railway extensions, but the provision of extensions alone will not develop the

agricultural resources of the countries. Consideration must be given to the second part of the economic axiom quoted at the commencement of this article, i.e. that the test of good management is to absorb as little as possible of the increased wealth (due to transport) in the process of achieving it.

There is in East Africa quite a considerable local market for agricultural products for internal consumption. This market is perhaps not as well developed as it should be, but the productivity of these territories is such that even if these local markets were developed to the full there would be a huge surplus which must be disposed of in markets outside East Africa. In addition, a number of commodities, such as cotton, sisal, etc., must be exported to find a market at all.

As East Africa is situated at a considerable distance geographically from the main markets of the world, and as the main route to European markets involves carriage by sea through the Suez Canal, it follows that if the agricultural produce of East Africa is to be marketed in competition with other producing areas it cannot bear heavy transport costs.

An examination of the general rate structure of East African railways reveals that the railway rates on exports, which as has been shown are in the main agricultural products, are extremely low compared with either the average costs of working or the highest rates charged. To this extent, the local rate structure differs considerably from the rate structure in more settled countries, where the range between the lowest and highest rates is much shorter than in East Africa. It is for this reason that reference is frequently made to the unbalanced nature of the rating tariffs of East African railways. It is an extremely important illustration of the extent of the relationship between railways and agriculture; the railways thereby expose themselves to considerable financial risk, as it increases their vulnerability to competition by other forms of transport to a tremendous extent. This is a matter which requires to be constantly borne in mind because at present no other form of transport can provide the services essential for the bulk export of agricultural commodities. It follows that if the railways are deprived of their more lucrative traffic the very basis of agricultural production is threatened.

To show more precisely the extent of this aid to agricultural production by means of cheap transport, the following figures are of interest.

In 1935 the average cost of haulage of public goods traffic on the Kenya and Uganda Railways and Harbours was 10.717 cents per ton per mile, which covers all charges including loan. The highest class rate charged on the railway brought in an average receipt of 107 cents per ton per mile, about ten times the cost, whereas the temporary rate on maize brought in 1.35 cents per ton per mile, about one-eighth of the average total cost. This represents an immense range between the highest and the lowest rates.

In Tanganyika, the average full cost figure was 16.568 cents per ton mile, the highest class rate 107 cents (the same as the Kenya and Uganda Railways), and the rate on rice 5.06 cents per ton mile.

Not only are the rates on exported commodities low in comparison with the average cost, but the quantities transported form a very large total of the tonnage carried. It is possible to find in other parts of the world very low rates, but as a rule such low standards apply to insignificant proportions of the total traffic.

Quoting again from the report of the General Manager, Kenya and Uganda

Railways and Harbours, the tonnage of exports carried to the coast (excluding soda, which cannot be classified as an agricultural product) represented 33.36 per cent of the total tonnage hauled in 1935. The following table illustrates the position during the past five years:—

	Per cent.
1931	30.59
1932	28.86
1933	35.58
1934	29.82
1935	33.36

These figures do not include agricultural traffic moved internally, which must be a very considerable quantity.

In Tanganyika, the principal agricultural commodities dealt with by the railway, internal and export, amounted to 53.66 per cent of the total tonnage hauled in 1936. For the past five years the percentages were as follows:—

	Per cent.
1932	51.97
1933	52.46
1934	48.38
1935	53.71
1936	53.66

Another interesting calculation has been made by the General Manager, Kenya and Uganda Railways, showing the relation between the ton mileage of maize, cotton seed and wheat and that of the total public ton mileage. All three of these commodities are carried at rates which return a yield of 3.08 cents or less per ton mile, and the following are the percentages for the past five years:—

	Per cent.
1931	33.1
1932	24.6
1933	29.1
1934	15.7
1935	22.8

When it is remembered that these figures relate to three commodities only, it shows what an important part the railways are called upon to play in agricultural production in East Africa.

Cheap transport by railways in East Africa is not confined to the direct production, but low rates apply to many agricultural essentials. Manures, fertilizers, agricultural machinery, gunny bags, are all rated very low in comparison with the high class rates. Port rates and charges on agricultural products are also low in comparison with the charges on imported commodities.

Another extremely important feature is that, for various reasons connected with pests, market prices and other factors, it is important from the producer's point of view that the export of the important agricultural commodities should be effected immediately the commodity is fit to be marketed, and, to avoid heavy expenditure on storage, that the movement should be completed in the shortest possible time.

Unfortunately, many of the crops mature at the same period of the year, so that the demands for transport also arise at the same time. This places an enormous strain financially and physically on the railway systems, and a cold review of the figures previously given does not illustrate this important factor. It is one that needs the greatest co-operation between agricultural and transport interests, and is not confined to one country but extends throughout East Africa.

Considerable progress has been made in this connexion between the agricultural industries in Kenya and Uganda and the railway in an endeavour to flatten out this peak movement, which is a source of considerable expense to the transport undertaking and inconvenience to the industries.

In a very careful review of costs carried out by the Kenya and Uganda Railways and Harbours some years ago it was calculated that the transport of one agricultural commodity under intensive peak conditions was 3.2 times the cost of

transport of the same commodity under normal conditions, and when consideration is given to the huge volume of agricultural traffic conveyed by East African railways, and the high proportion it is of the total traffic, such an increased financial burden is a serious matter.

There is yet one other important relationship between the railways of East Africa and the agricultural industry, and that is the relationship of buyer and seller. It is probably not exaggerating to say that the railways are the largest local customers of the agricultural industry. The two East African railways employ 25,000 Africans, and the terms of the employment of most of the Africans includes provision of rations in addition to monetary payments. This in turn involves the local purchase of large quantities of agricultural products grown in these territories.

In every phase therefore of transport the relationship with agriculture becomes apparent, and in almost every phase of agriculture the desire for efficient transport is necessary, even to the conveyance of native passengers to and from employment.

There have in the past been differences over the policy to be followed, but that there has also been a high degree of co-operation is evident from the results tabulated in this article, and it can be said generally that both agriculture and transport have played their full part in the development of East Africa. There seems no reason to suppose that the relationship between these two important economic factors will in any way diminish in the future. There is, in fact, every reason to anticipate that the relationship will be even closer.

The "Letting Down" of Milk

It is rare to find any herd of native cows being milked without, at the same time, the calves being allowed to stand by their mothers' heads. The reason for the procedure, we are told, is that otherwise the cows will not let down their milk. This suggests some voluntary restraint on the cow's part, exercised as a protest against removal of a mother's privilege, but according to J. Hammond, in an article on "The Physiology of Milk and Butterfat Secretion," which appeared in the *Veterinary Record* of 25th April, 1936, the explanation is otherwise.

Although the cow's udder is usually described as consisting of only two glands, the right and left, separated by a double septum, yet as each "quarter" of one side discharges separately into its own cistern, no false idea is created by speaking of the four glands of the udder. One may think of one of these glands as something like a close bunch of grapes packed tightly in cotton-wool and put in a bag. The bag is the thin elastic skin which encloses the udder. The cotton-wool is the supporting interstitial or fleshy part of the bag, and throughout it run nerves and very many blood vessels. The grapes are the true glandular tissue, the lining cells of which take up material from the blood which flows near them and reorganize it to form milk. This picture of my own is a poor one, because it conveys nothing of the complexity of the terminal glands represented by the grapes, but it does show that the mere size of the distended bag is no true indication of milking capacity, since an unknown proportion is connective tissue—the cotton-wool of our figure. An ideal bag, composed mainly of glandular substance, with just enough connective tissue to support it and carry the blood vessels which feed it, "shrinks away to nothing" after the milk is withdrawn, and expands easily as milk is secreted into it. As Hammond says: "The whole structure of the cow's udder appears to be designed for the relief of pressure on the secretory alveolar cells."

While milk is being secreted, blood is pouring through the vessels of the udder. It has been computed that 300 to 400 volumes of blood must pass through a gland for each volume of milk secreted, so one can see that during the actual time of milking there is not much time for much milk to be secreted. Hammond emphasizes this, and points out how erroneous is the old idea that a large proportion of the milk is secreted during the time of milking; during this time it is merely let down from the terminal parts, or alveoli, of these complicated glands.

It has been shown conclusively that all the milk obtained during the milking time of ordinary duration is present in the udder when milking starts. Why then cannot it be drawn from the ordinary native cow unless her calf be present? To answer this we must revert once more to the mechanism of secretion.

It is obvious that as milk accumulates in the gland it exerts pressure on the secreting cells, making it harder and harder for these to do their work. The reason for inflating the udder in milk fever is to raise pressure and stop secretion. Normally, by the time the cow comes into the milking shed the cistern is dilated, the ducts are distended and the alveoli are full. If we were to kill the cow instantaneously we should not be able to extract by milking more than half the quantity of milk obtained by normal manipulation of the living animal—the milk would not be let down. What happens when a calf sucks, or when a trained

cow is correctly milked, is a reflex engorgement of the blood vessels of the udder, constituting an erection, and this engorgement presses the milk from the alveoli through the ducts and into the cistern as room is made for it by milking. "It can be observed that, when a sow lies down, there is a latent period before the milk is let down, as would occur if some mechanism such as erection were involved in the process. For a short time there is a noise and commotion as the piglets nudge at the teats and the late arrivals are finding theirs; then suddenly all is silent and still—the milk is let down in all the nipples at the same time, to the late arrivals as well as the earlier." We have all noticed how calves and lambs punch the udder to make the milk come down; the erection being a psychological and physical response to a pleasurable stimulus. The trained European cow responds in the same way to manipulation by the milker's hands, and a good milker is one who soothingly and rapidly stimulates maximal erection. Now the native cow is used to responding to the stimulation of her calf's sucking and nudging, but she is upset and worried when similar manipulation is unaccompanied by the familiar sight and scent of her calf; little or no erection occurs, and only the little milk which is in the cisterns and larger ducts is procured. If the calf is present, the cow tends to respond to the milker as though her offspring itself were manipulating the udder; erection is stimulated and the milk is let down. At Ngong the same result is achieved by allowing the cow to smell and lick a piece of hide on which slime from the newly-born calf, or, later, milk from the cow herself, has been smeared. The purpose is to induce the pyschological state necessary for erection to be evoked by milking; for it is this erection which results in milk being let down.

H. E. H.

Waterholes for the Conservation of Flood Water*

By E. J. VAN MEERTEN, *Engineer, Department of Agriculture and Forestry, Union of South Africa.*

On account of the nature of the area, it is impossible on many farms to make provision for water for stock in the form of a dam as usually constructed.

Therefore the so-called "waterholes" are accepted under the Soil-Erosion Scheme, and it is felt that while until now all types of waterholes have been constructed, an effort should be made to standardize these waterholes as regards design.

Accordingly, in the following pages, a description is given of the standardized waterhole in respect of which the Department of Agriculture and Forestry is prepared to grant financial assistance under the Soil-Erosion Scheme. Particulars of this financial assistance may be obtained from the magistrates in the areas concerned.

General Nature of the Waterhole

The arrangement consists of a hole or dam of suitable depth, having a square bottom, and three sides with a slope of 1 : 1, while the fourth side, the entrance, has a slope of 1 : 3. Around the hole the excavated soil is made into an earthen wall in the shape of a horse-shoe, the open end, which is provided with two short wing-walls, being on the side at which run-off water from the veld enters the hole.

The entire waterhole and wall are enclosed with a fence forming at the open end a gangway down to the bottom of the hole. The gangway is stone-pitched or covered with suitable wooden poles or railway sleepers, so that stock will not be able to trample the soil to mud.

Site and Dimensions

The waterhole will usually be constructed in a very flat vlei or valley, where run-off water flows slowly. The soil at the site where the hole is to be made must be of such a nature that it will hold water and where it will not seep away too soon. Therefore, sandy soil should be avoided. Stony soil and hard gravel banks must also be avoided as far as possible, as then the cost of the waterhole becomes excessive in proportion to the capacity.

The dimensions of the hole depend on requirements, but in general it will be better to make it fairly deep rather than very long and wide, as in that case evaporation of water from the surface will be unnecessarily great. The bottom of the whole is square.

Setting Out the Hole

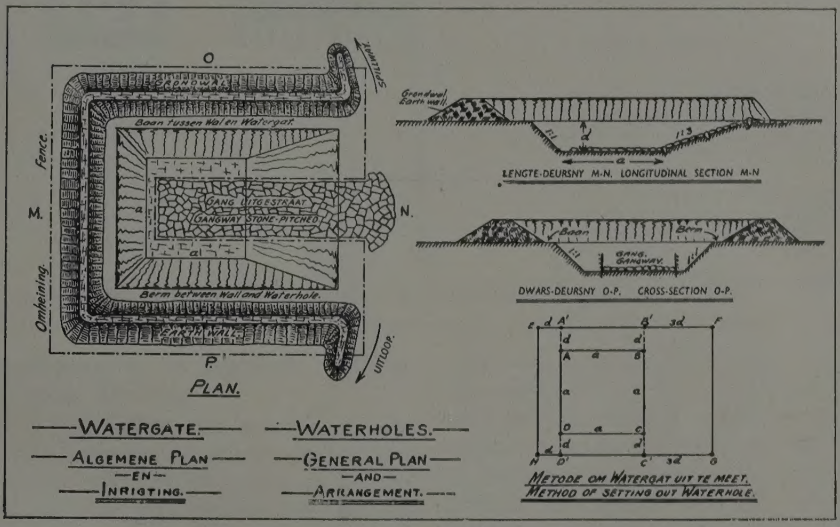
See "Method of Setting out Waterhole" on the plans. After the dimensions "a" of the bottom have been decided on, a square ABCD is set out with temporary pegs on the site chosen. Then permanent pegs A^1, B^1, C^1 and D^1 are driven in at distances "d" from the others, "d" being the same as the proposed depth of the hole, in feet. Permanent pegs E and H are driven in at distances "d" from A^1 and D^1, and pegs F and G three times the distance "d" from B^1 and C^1, as shown on the sketch. Pegs A^1, B^1, C^1, D^1, E, F, G and H should be iron pegs which are not liable to be ploughed out or trampled down.

Construction

It is assumed that waterholes will be constructed, as far as possible, with plough and scrapers, and finished off

* Reprinted from *Farming in South Africa*, Vol. XII, January, 1937.

with pick and shovel to trim off to the correct slopes the sides, the back and the entrance. Plough and scraper work will commence on the line F-G and finish on E-H, while outside the lines E-F and G-H no ploughing or scraping should be done. The hole will first be ploughed and scraped out until the desired depth is reached at about the centre of the area between pegs EFGH. To determine whether or not the depth is correct, a string line is stretched across the excavation, on the ground surface, and measurements are taken from this line downwards.



During excavation care must be exercised to see that the sides receive a 1 : 1 slope, and the sides must therefore be drawn in gradually. The excavated earth is dumped all round the hole, and care must be taken to provide for a berm of not less than 4 feet wide between the inside toe of the earthen wall and the top of the excavation. When the correct depth has been reached, the hole can be scraped out further, until the entrance slope is found to end below the line B^1-C^1, at the correct depth. At the other end, ploughing and scraping may continue until the draught animals can no longer climb up the slope. The bottom is then made level and string lines stretched between the pegs B^1 and C^1 and between A^1 and B^1, with plumb lines fixed at distances "d" from the pegs and let down to the bottom, where they will again indicate the points A, B, C and D. Further, the sides and back of the waterhole are trimmed off with pick and shovel so that these three sides will receive a 1 : 1 slope. The entrance will automatically receive a 1 : 3 slope.

The ends of the horseshoe-shaped earthen wall are turned to form short wing walls, as on the plan.

Fencing and Pitching

After the waterhole and the earthen wall have been built, a fence is erected all round, to keep stock off the wall. At the entrance, the fence, as is shown on the plan, is turned down to the bottom to form a gangway which is closed at the end. The width of the gangway should be not less than 12 feet.

The whole gangway is pitched or paved with stone up to the top, and where the

pitching reaches the surface, the stones at the entrance may be let into the ground to prevent them from being trampled out.

If stones for pitching are not available, the gangway may be paved with round poles or old railway sleepers, but old wooden sleepers which have been treated against rotting with a poisonous preparation *should not be used*. Therefore, iron sleepers are better. The object of the pitching is to prevent the waterhole from being trampled to mud.

If poles or wooden sleepers are used, they must, of course, be anchored down, to keep them in place when there is water in the hole.

Object of Earth Wall

Since, in any case, the excavated earth must be disposed of somehow, the object of the earthen wall is to impound a little extra water after the hole has been filled. Excess water is then diverted by the wing walls into the veld.